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Project Title: Development of Correlational Reasoning.

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ABSTRACT

For large-scale projects, please provide in the space below an abstract of not more than 300 words, single-spaced, written in a language that may be understood by the informed layperson. For small-scale projects, an abstract per se may not be appropriate, and the report itself may be started below.

A substantial proportion of the knowledge provided to students in schools and in out-of-school situations is based upon correlational inquiry. For example, they are told that temperature increases as one gets closer to the equator and that drinking drivers have more accidents than non-drinkers. Students are rarely given instruction in how to solve correlational problems on their own. Consequently, they have difficulty when given a correlational task and many leave school lacking the skills to debunk invalid claims, such as the nonexistent link between race and good citizenship. The study reported here is part of a multi-year project to improve student acquisition of correlational reasoning skills. In 1989-90, developmental profiles of student growth under conditions of existing instruction were constructed. These profiles were based on the analysis of responses to open ended tasks of samples of students from grade 5 to university. An instructional intervention involving grade 7 students was pilot tested with substantial student improvement. Contrary to expectation student and teacher characteristics did not interact with the effects of instruction.

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through its block Transfer Grant
to OISE.

DEVELOPMENT OF CORRELATIONAL REASONING

Goals

1. To identify patterns of student development in correlational reasoning skills.

2. To develop and evaluate alternative strategies for teaching correlational reasoning: a whole class approach, a cooperative learning approach and a computer assisted cooperative learning approach.

Motivation For the Project

Correlational reasoning skills are an essential part of many school subjects especially in the Ministry's Intermediate/Senior Guidelines for Geography, Science and Mathematics. Correlational problems are also relevant to real life tasks in which the main difficulty is dealing with illusory correlation--recognizing that despite superficial appearances based on limited data, certain variables are not related. The task is a challenging one even for sophisticated adults (Ross & Lepper, 1980). One of the most important contexts for coming to grips with false correlations arises when claims are made about relationships between racial membership and measures of good citizenship; stereotyping may be the result of incorrect correlation (Jennings, Amabile, & Ross, 1982).

Previous research indicates that correlational reasoning skills develop very slowly, if at all, under conditions of existing instruction. Slight age trends have been reported by a few cross-sectional studies (Adi, Karplus, Lawson & Pulos, 1978; Kuhn & Brannock, 1977; Lawson & Bealer, 1984; Shaklee & Mims, 1981; Shaklee & Paszek, 1983). Others have found no differences between the performance of students in grade 7 and grade 10 (Ross & Maynes, 1981), grade 7 and college (Koslowski & Okagaki, 1986) and even grade 6 and college (Lawson, 1982).

The impetus for the project comes from an appreciation of the importance of correlational problem solving in cognitive development and the recognition that relatively little researcher attention has been devoted to this important class of problems in comparison to the attention given to other problem types such as proportional reasoning or experimentation. The relatively few studies that have been produced comprise a relatively weak research base due to deficiencies with respect to the range of skills covered, the conceptions of skill and the instructional treatments that have been developed.

Review of Previous Research

Definition of Correlational Reasoning Skills

Correlational problem solving involves finding the degree of association between two or more variables which cannot be physically manipulated by the problem solver. In instructional contexts, reasoning about correlation might more properly be labelled regression because it typically refers to the search for causal relationships. Correlational problems are intuitively similar to experimental problems and for this reason science educators assign both types to the same category of objectives--integrated science processes. Some learning theorists have also put both types in the same category. For example, Piaget included both in formal operations, the highest level of cognitive functioning, arguing that correlational reasoning is prerequisite to experimental reasoning (Inhelder & Piaget, 1958).

There is substantial empirical evidence that performance on the two types is independent. For example, when Yap & Yeany (1988) attempted to construct a learning hierarchy of formal operations and integrated process skill items, they found that correlational reasoning did not fit into the hierarchy while the remaining constructs did. Similarly, Baird & Borich (1987) found that when they factor analyzed a large set of formal operations items, the correlational items did not load on the same factor as the experimental items: the average inter-item correlation between the two problem types was only .25. In addition, Kuhn & Brannock

(1977) have provided a theoretical argument, based on an analysis of the task requirements of the two types, encouraging separate instructional treatment of correlation and experimentation.

Previous Conceptions of Growth

A computer search of research data banks (Resources in Education, Current Index to Journals in Education, Ontario Educational Research Information Service and Dissertation Abstracts) and subsequent manual branching through the references identified in the first round of "hits" identified 19 studies. Each of the studies listed in Table 1 investigated the development of correlational reasoning skills in a multi-age sample or provided information on the effects of an instructional intervention.

Table 1 About Here

The first column of the table identifies the study; those which report the results of instructional interventions are marked with asterisks. The second column describes the samples that produced the data: the samples tended to be small and were well distributed across age ranges, although few examined primary children, and within studies the range of performance surveyed was fairly narrow. The third column reports the method of data collection: almost half used individual interviews with the remainder evenly split between multiple choice measures and open ended paper and pencil tests.

Columns four and five of the table show there has been considerable diversity in the complexity of tasks administered to students. In over half the studies subjects were required to find a simple correlation involving only two variables. The remainder focussed on multivariate problems containing up to seven variables. A similar proportion examined correlations between continuous (interval scale) variables. Most of the remainder looked at categorical variables (almost all were dichotomous). In most studies the only tasks subjects received were those in which there was a relationship to be found; only a few investigators provided tasks in which subjects had to find that variables were not related. This is a serious shortcoming in that the discovery of pseudo-correlations (e.g., between race and measures of good citizenship) is an important dimension of correlational reasoning in every day life. Donnelly & Welford (1989) found that most 15 year olds were

> ...not able to operate criteria for the elimination of "relationships"...the constant emphasis on relationships, and the limited attention to unrelated data, has an effect here, so that the possibility of the absence of a relationship is resisted (or) pupils may have difficulty deciding when an "effect" is so embedded in random variation or operates in so narrow a range as to be neglected.

In contrast, subjects in the Adi et al. (1978) study were given 20 cases in each of three trials: one set showed a positive correlation; another showed a negative relationship and the third was a nonrelationship. A similar strategy was followed by Prentice (forthcoming). Several investigators (Kuhn & Brannock, 1977; Kuhn & Ho, 1977; Rowell & Dawson, 1984, 1985) administered tasks in which subjects had to recognize that one variable influenced the outcome while others did not.

The sixth column distinguishes between "levelled" and "criterion" definitions of growth. For example, Lavoie & Good (1988) defined the ability to make a correlational prediction in terms of a hierarchy of four levels: at the lowest level, students are able to predict that two factors will be related in some way ("oxygen and temperature will go together"); at the next level students predict that variables will covary but are unable to predict how ("oxygen will change when temperature changes"); in the next they indicate direction ("oxygen will decrease as temperature increases"), and at the highest level a ratio relationship is predicted ("for every rise of one degree of temperature, oxygen decreases 3 ppm"). These "levelled" conceptions of skill growth play a key role in the design of instruction in that specification of increments of learning reduces the burden on learners; it makes it easier for teachers to set realistic but challenging goals for each student and it helps focus feedback and remediation (Robinson, Ross & White, 1985). A quarter of the studies developed a less precise, and less useful, conception in which student growth is defined in terms of mastery of a given criterion. For example,

Prentice (forthcoming) defined mastery of prediction as a statement of the direction of the relationship between two variables ("temperature will increase as latitude decreases"). Even though most studies provided a levelled conception of growth, many of these conceptions were developed a priori (typically through logical analysis of task demands) and imposed on the data. In contrast, current cognitive research, particularly with respect to children's grasp of concepts (see, for example, the review by Gilbert & Watts, 1983), suggest that ideas about development be generated a posteriori from student responses.

The seventh and last column of the table describes the skills that were addressed in the studies. Correlational reasoning can be broken down into a series of connected subskills corresponding to the Interdisciplinary Skills List (Robinson, Ross & White, 1985), an outcomes organizer that has been useful in the improvement of children's problem solving skills in a variety of domains. For example, a problem solver undertaking a correlational inquiry involving the relationships among a set of variables would (a) make a set of predictions about the expected relationships among these variables; (b) organize these predictions in a framework or model; (c) obtain data to operationalize the model; (d) process information within the framework and (e) report the results. Each of these steps can be viewed as a discrete skill, consciously performed, and amenable to instruction. None of the studies in Table 1 addressed all five skills and most were limited to a single skill, usually data processing.

The studies also differed in terms of which dimensions of growth within skills were given attention. There was considerable agreement within the studies addressing the skill of predicting: there was a shared interest in students' ability to predict the direction and magnitude of relationships. The differences on the other skills were substantial. The studies can be grouped into three categories: The Kuhn/Rowell cluster of studies emphasized the ability of older students to control variables in designing a correlational inquiry and in interpreting the results. In contrast, the Piaget/Shaklee cluster of studies was unconcerned about controlling variables; their interests focussed on the ability of younger students to construct a simple 2 X 2 data table and to determine whether the variables in the table covaried. The Robinson/Ross/Prentice cluster attempted to embrace both sets of dimensions. Even within these clusters there were differences in dimensions or levels. For example, the Shaklee studies followed the Inhelder & Piaget (1958) growth scheme for analyzing correlational data until the highest level. Shaklee and colleagues argued that the use of the procedure in this level would lead to error in a small but important number of cases: an additional level was therefore added to the growth scheme.[1]

In summary, previous research on correlational reasoning is deficient in several ways:

1. There has been substantial variation in the complexity of tasks assigned to subjects and the most important have been given less attention. Most investigators focused on two variable problems, even though students are more likely to encounter multivariate tasks in school settings and in out of school contexts. The majority of studies did not provide data sets calling for the finding of a nonrelationship, even though the ability to debunk false correlational claims is an important and challenging responsibility of literate adults. Most of the tasks assigned to subjects were limited to dichotomous variables, even though a large proportion, if not the majority, of data that students will encounter are continuous.

2. Although most of the studies reported levelled rather than criterion conceptions of student growth, the origins of the levels are in doubt. Few investigators reported growth schemes which were derived from empirical data.

3. The utility of previous research is further reduced by investigators' choice of skills: coverage has been incomplete and there are too few studies in each category to permit credible generalization.

Previous Research on Instruction

Seven of the studies attempted to improve correlational reasoning through instruction. Most were successful. Shaklee, Hall & Paszek (1982) found that young children's ability to

process information in a simple 2 X 2 table could be improved by giving them a procedure that consisted of counting the cases in each cell and comparing the totals of the cells in each of the diagonals to the totals for each of the columns. Shaklee & Paszek (1983) subsequently found that treatment students outperformed controls even when the treatment consisted of merely counting the cases in each cell, although the gains were not as large as with the longer procedure. Rowell & Dawson (1984, 1985) also reported an effect for rule based instruction, but the results for the correlational items were embedded in a summative score that contained results for other items. Prentice (forthcoming) found that giving students explicit rules for solving a correlational problem had a positive effect on their ability to predict, frame and process data. Similar results were obtained by Popp, Robinson & Fast (1975) and by Ross & Maynes (1983a), but both these studies lacked control groups. In contrast, Curtis (1985) found that an exploratory data analysis procedure delivered via a computer software program had no greater effect on undergraduates' data processing skills than a traditional statistics course.[2]

In summary, the instructional investigations offer grounds for optimism that providing students with appropriate procedural knowledge will lead to improved performance. Previous research is limited in several ways:

1. There have been relatively few studies and these were divided among several different conceptions of the skills to be developed. The studies do not cumulate into a coherent corpus.

2. The set of studies is further reduced by those with serious design flaws (Popp, Robinson & Fast, 1975; Ross & Maynes, 1983a) and those which use delivery methods, such as one to one instruction (Shaklee, Hall & Paszek, 1982; Shaklee & Paszek, 1983) which are not easily adapted to the classroom.

3. There has been little interest in teacher and student characteristics that might interact with correlational reasoning instruction.

A four stage project is underway over a three year timeline to remedy these deficiencies in research on correlational reasoning. The results from Phase I and II are reported here. Phase I focused on the development of an empirically based conception of student growth. Phase II was devoted to the development of a whole class version of an instructional program for grade 7 and for grade 9/10. Subsequent phases will explore instructional alternatives. All phases of the project are being undertaken in collaboration with representatives from four school boards in eastern Ontario.

PHASE I
DEVELOPMENT OF CONCEPTIONS OF STUDENT GROWTH

The growth schemes representing the development of correlational reasoning skills were progressively developed over a three-step process. Each step was marked with a data collection to ensure that the conception of student growth was empirically based.

Development of Initial Growth Schemes

Instruments

The review of previous correlational reasoning research provided four criteria for specifying the complexity of the task to be performed by students: (a) the task should involve the performance of a range of skills rather than be limited to processing data alone--since there has been no research interest in reporting a correlational investigation the project focused on the skills of predicting, organizing information in a framework, obtaining data and processing data; (b) the task should be multivariate rather than bivariate; (c) the variables should be continuous rather than dichotomous; (d) subjects should be required to exclude, as well as include, relationships. A fifth criterion was added: (e) the task should make limited knowledge demands on subjects because tasks which combine heavy skill and knowledge demands create problems of cognitive overload that reduce performance. For example, there is substantial evidence that students are more likely to control variables in experiments involving familiar

topics (Linn, Clement & Pulos, 1983; Linn & Levine, 1978; Linn & Swiney, 1981; Ross, 1988a). There is also evidence that skill items that make limited knowledge demands are more effective in detecting the effects of instruction (Ross, 1988c).

Correlational reasoning instruments used by previous researchers were examined but none met all five criteria for task complexity. Consequently a new instrument was developed. The instrument provided subjects with data for 18 cases; for each case there was information on a child's age, sex and how far the child swam in two minutes. The following directions were given:

> Mrs. Campbell, the swimming coach, tests the swimming team every week. Here are the results from last Saturday (distance in 2 minutes).
>
> (a) Does swimming have anything to do with age? Write a sentence that says how they might be related.
>
> (b) Find out if swimming is related to age. Use only the information given in the the table. Show your work.

Sample

The instrument was administered to multi-age convenience samples. There were 20 respondents (half male, half female) in each of grades 4, 7, 10, OAC (grade 13) and university undergraduates (all university students had taken one course in statistics and were enrolled in a third year Honours Geography course). The instrument was administered by students' teachers, with the exception of the grade 7 sample that was administered by the school principal in the presence of their teacher. Students were told that the test would not count toward their final grade and that the results would be used for research. No time limits were assigned; most students finished in less than 20 minutes.

Analysis

Prior to the first analysis session the student responses were quickly scanned by the board representatives to select a high, medium and low response from each grade. No criteria were provided for the selection; the judgment was quick and intuitive. At the first session the researchers provided a set of expected dimensions for each skill which were derived from previous attempts to describe student growth in correlational reasoning; for example, for the skill of organizing information in a correlational problem, previous investigators have focused on whether/how the data are grouped. The analysis team began by examining a medium grade 4 response and a medium university response to see if the differences between them reflected the expected dimensions for each of the skills of interest. New dimensions were added as required.

The second analysis session involved specifying levels for each of the dimensions using the three examples from each grade. In doing so new dimensions appeared. At this stage the analysis team tried to be as inclusive as possible. For some dimensions there appeared to be levels that were logically compelling even though they had not appeared in the responses; these were added to the developing hierarchies in italics to differentiate them from observed responses. Figure 1 contains an example (for the skill of organizing correlational data into a framework) of a multi-strand growth scheme produced at this stage of the analysis. For each of the levels a reference to a specific case was provided, except where the performance was so common (e.g., having no control variables) that it was unnecessary. Figures 2 to 6 provide examples of responses for the key dimension of this skill.

Figures 1 - 6 About Here

The third analysis session consisted of expanding the growth conception by examining each of the remaining responses. There was a continual modification of the schemes to find the best representation of response diversity. Levels which were logical but not observed were dropped at this stage. In addition the schemes were reduced in complexity by selecting only the

most frequently occurring levels and by combining dimensions and levels whenever possible. The result was the construction of a series of single strand growth schemes. There was one growth scheme for each of the skills of predicting, obtaining data and organizing information. The skill of processing data could not be reduced to a single strand; it was broken down into two skills, labelled "synthesizing information" (being able to summarize data to find a relationship) and "drawing a conclusion" (describing the relationship). An example of a single strand growth scheme is given in Figure 7.

Figure 7 About Here

Results

The analysis of the first data collection resulted in the development of an initial conception of student growth that provided a series of levels of increasingly sophisticated responses to the task. Although the analysis began with a set of expectations derived from past research, the levels became empirically grounded through successive iterations through the data.

The analysis revealed that the instrument needed to be modified. It was observed that not all students followed the directions in the prescribed order: many examined the cases prior to making a prediction. In addition, many students did not provide an explicit conclusion, possibly because the item did not overtly call for one. They provided charts, graphs, pictures and calculations, but it was very difficult to determine whether they believed the variables in the task were related, and if so, how. There was also doubt in some responses as to whether the effect of the control variable had been examined, because the relationship between age and swimming speed was virtually the same for boys as it was for girls in the data provided by the stimulus.

Other aspects of the data collection also evoked concern. It was feared that because only a single task was administered, the growth schemes might be too dependent upon the swimming content. In addition, some adjustment of the multi-grade sample was required when it was observed that most grade 4 students had no idea how to proceed on the task and a large proportion of this sample submitted totally blank responses.

Refinement of the Growth Schemes

Instrument Refinement

The swimming instrument was revised in response to the first data collection. The directions to students were given in three parts. Students were required to make a prediction on the first page ("Are taller students faster swimmers than shorter students? Write a sentence that says how [or if] height is related to swimming speed."), and having done so this page was collected. The second page was then distributed. This page contained the task situation and the raw data for the problem; students were asked to "Find out if there was a relationship between the height of students and how fast they swim. Use only the information in the table. Show your work." Then they were asked to "Write a sentence that says how (or if) height is related to swimming speed." In addition, the data were reworked so that the correct interpretation would find that height and swimming speed were positively related for boys but not for girls.

A new instrument was created having exactly the same form and data distribution; the wording of the directions was identical except for the variables. The content of the task was a hockey problem; students were given data on 18 players' experience (new or old players), height, and the distance skated in 15 seconds. The correct interpretation of these data would find that height and skating speed were positively related for old players but not for new ones.

Sample

The instruments were administered to multi-age convenience samples who were not involved in the first data collection. There were 20 respondents (half male, half female) in each of grades 5, 7, 9, 11, OAC (grade 13) and adults enrolled in a Masters of Education course on program evaluation. The instruments were randomly assigned such that each was completed by

10 subjects in each grade. The instruments were administered by the classroom teacher for the grade; all other procedures were identical to those used in the first data collection.

Analysis

All of the responses were independently coded, one grade at a time, by two of the investigators. After each coding the proportion of exact agreement was calculated and differences between coders were resolved. In some instances this led to the revision of the growth schemes; in others it led to greater understanding between the coders of operational meanings. The inter-rater reliability ranged from .72 (for the grade 7 sample) to .87 (for the M.Ed. sample); overall it was .77, substantially below the .90's obtained by trained testers in other projects undertaken by the investigators (e.g., Ross, 1988b). The low reliabilities might be attributed to two factors: the coders were constantly revising and learning the schemes as they went along, and the coding was interrupted by lengthy delays, typically greater than a week, between each coding. Coding difficulties were particularly apparent in the skill of predicting, and, to a slightly lesser extent, in the skill of concluding; agreement on the other three skills was higher.

Results

The second data collection resulted in the refinement of the growth schemes; these are provided in Appendix 1. The differences between this version and the original conception are small but important. Appendix 1 also contains the distribution of scores on each growth scheme by grade. These findings show that some skills develop more quickly and more completely than others; locating data is the easiest; synthesizing the most difficult. The results indicate that observed performance is a long way from the ideal. No one in the first or second data collection (a total of 220 respondents, including 80 at OAC or university) met the Ministry Guideline expectations for the end of the Senior Division. At each grade level the performance was below the desired levels.

The second data collection also showed that there were continuing difficulties with the instruments. The coders had difficulty in dealing with students who came up with a correct or partial conclusion even though they had no apparent strategy for interpreting the data. It seemed that some students' beliefs about height and athletic performance were congruent with the data provided in the instrument. This may have inflated scores. In addition, the low inter-rater reliabilities evoked concern.

Consolidation of the Growth Schemes

Instruments

A new instrument was produced to deal with students who were able to generate a correct conclusion from their belief systems. In the new instrument subjects were asked to predict whether the amount of vaccine administered to students in 18 schools was related to the number of flu cases in those schools. The data in the latest version of the item support a counter-intuitive finding (the vaccine increases the likelihood of getting the flu) that becomes clearly visible only when students control for a third variable (the form in which the vaccine is delivered): The number of cases of flu increases with the amount of vaccine given in pill form; in needle form there is no relationship between the amount of vaccine and the number of flu cases. The swimming instrument was revised to produce a similar finding: height is negatively related to swimming speed for girls and is unrelated to swimming speed for boys. Appendix 2 contains the instruments, administration directions and scatter plots of the data. The hockey instrument was not used.

Sample

The instruments were administered to multi-age convenience samples who were not involved in the earlier data collections. There were 20 respondents (half male, half female) in each of grades 5, 7, 9, 11 and OAC (grade 13). The instruments were randomly assigned such that each was completed by 10 subjects in each grade. The instruments were administered by

the classroom teacher for the grade; all other procedures were identical to the earlier data collections.

Analysis

Given the difficulties with interpreting students' predictions, a decision was made to limit the analysis to four skills: organizing information, locating data, synthesizing and concluding.

The responses were randomly assigned to 10 packages of vaccine items and 10 packages of swimming items. Each package contained one response from each of the five grades, arranged in random sequence. Grade 7 Geography teachers (n=16) were invited by board representatives to attend a half day workshop on correlational reasoning. At the workshop teachers received a rationale for addressing correlational problems, a demonstration of a procedure for solving them, and a series of small group exercises to provide practice, with feedback, in solving correlational problems. Examples of student work were displayed to show how student performance changes; these changes were represented as a series of growth schemes.

The first package of items was used to demonstrate the application of the schemes. During the demonstration and discussion a marking scheme was constructed to facilitate coding. Figure 8 gives this scheme in slightly revised form. Teachers, in groups of four, then coded a second package of multi-grade responses. After feedback and large group discussion, individuals independently coded a third package and shared the codings within their groups. The workshop ended with each individual independently coding two more packages, one for each instrument; 16 packages were each coded independently by two teachers.

Figure 8 About Here

Results

The proportion of exact agreement ranged from .58 (for concluding) to .80 (for locating data); the overall inter-rater reliability was .72. The low reliability might be attributed to the coders' insufficient knowledge of correlational reasoning. None had taught the skill and for most the workshop was their first introduction to this type of problem. The generally low performance of the students meant that markers rarely saw examples of higher skill levels. In addition the grade 7 teachers may have been unfamiliar with the expressions of students in grades other than their own.

PHASE II
DEVELOPING WHOLE CLASS INSTRUCTION

Phase I of the project produced convincing evidence that Ministry expectations regarding student mastery of correlational reasoning skills are not being met. Phase II of the project consisted of an instructional intervention that was intended to answer three questions:

1. Can students' correlational reasoning skills be improved through whole class instruction?

2. Is student learning affected by students cognitive styles--field dependence/independence and locus of control?

3. Is student learning affected by teacher efficacy?

These questions were addressed by designing an instructional module for grade 7 and field testing the module in a pre/post control group design.

Treatment

The treatment consisted of a correlational reasoning module using climate content, a grade 7 Geography topic. Appendix 3 contains the module. The duration of the treatment was

nine 40-minute periods. The instructional strategy was a "rules provided" method (Robinson, Ross & White, 1985) that has produced substantial student achievement effects in other problem solving programs (e.g., Maynes & Ross 1984; Ross, 1986, 1988b, 1988c, in press; Ross & Maynes, 1983a, 1983b; Ross & Robinson, 1987). There were three components.

Lesson 1 (four periods) was designed to enlist student motivation, demonstrate a procedure for solving a simple correlation problem and distinguish among three types of correlational relationships. The lesson began by having students rate how they felt in terms of a "feeling thermometer" with a scale from 0 to 100. They then rated themselves at different points during the day to create a simple graph and the teacher demonstrated how changes in the ratings could be used to find relationships; e.g., a student's ratings might become increasingly positive as the time for lunch approached. Students were given examples of other patterns in day-to-day life (e.g., "why do you do better on some tests than others? could your test scores be related to how hard you studied? or how much you liked the subject?") and were encouraged to think of others that were meaningful to them.

The teacher demonstrated how to find a correlation using the procedure in Figure 9 in the context of the question, "Do people who drink and drive have more accidents than nondrinkers?"; the result was a positive correlation. Students were given practice in finding other positive correlations in a problem involving sports ("Is the amount of time spent in extramural sports related to marks?") or basketball ("Is there a relationship between the height of players and the number of points scored?"). In Lesson 1 teachers were encouraged to select practice activities from two levels of difficulty: simple practice provided students with 8 cases to deal with; more difficult practice provided 12 cases. Feedback to students focused their attention on the three steps of the procedure: make a graph, put information in the graph, and read the graph. The teacher then demonstrated a negative correlation by using the procedure to find that the number of accidents decreases with age. Student practice involved finding negative correlations between television watching and student achievement or between student weight and flexed arm hang time. Following feedback that focused on the procedure, the teacher demonstrated a noncorrelation by finding that the size of cars does not affect the number of accidents. Student practice consisted of finding a noncorrelation between height and achievement or between height and batting average. The three types of correlation (as shown in Figure 10) were reviewed and students were given several scatter plots for which they had to draw a trend line and describe the resulting correlation. The lesson ended with a short quiz (given a set of data find out if the amount of crime in a shopping centre is related to the number of lights) that was individually marked.

Figures 9 & 10 About Here

Lesson 2 (two periods) consisted of applying the procedure to Geographic contexts. Students were given a set of data consisting of information on latitude, longitude and temperature for 12 weather stations and a scenario such as:

> "Look at this, I'm already a winner!" said John as he ripped open the envelope from Sleazy Promotions Limited. "All I have to do is subscribe to six magazines and I'll win an African safari. It goes right across the continent so I'll need heavy clothing at the beginning and lighter clothing the farther west we go." "I don't think you have to worry about it", laughed Steve. "Sleazy Promotions is not the most reputable of firms. Besides everybody knows that if you want to get warm you go south, not west."
>
> Who is right - John or Steve? Use the information in the tables to find out if (a) latitude and temperature are related. Then find out if (b) longitude and temperature are related. Remember to make one graph for each correlation.

Teachers were encouraged to select from three levels of practice difficulty. The simplest involved data from North America which confirmed student expectations that it gets warmer the farther south one goes. Medium difficulty practice contained South American data which contradicted student expectations because south of the equator it gets colder the farther south one goes. The most difficult practice involved African data because students had to plot the

cases using distance from the equator without regard to whether one was north or south of it. Feedback on practice focused student attention on the knowledge outcomes (latitude and temperature are negatively correlated and there is a noncorrelation between longitude and temperature) and on the procedure for finding a correlation.

Lesson 3 (three periods) was devoted to expanding the procedure to handle multivariate problems. The lesson began with data on elevation, temperature and latitude from four weather stations in each of three continents. Students were asked to find the relationship between elevation and temperature in each continent. The result was three graphs showing three different relationships--a positive, negative and noncorrelation--which were explained in large group discussion by the failure to control for the effects of latitude. Students were given some misleading correlations from everyday life (e.g., "A medium size pizza at Lorenzo's costs less than a small pizza at Zeppi's. Should we conclude that there is a negative correlation between pizza size and pizza price?") and were asked to find the missing variable (e.g., "More toppings mean a higher price so if we want to know if the size of the pizza is related to its cost, keep the number of toppings the same.") Students were then given data from 12 weather stations on distance to large bodies of water, hours of sunshine, average temperature, temperature range, and latitude. They were asked to investigate two sets of relationships, each involving a temperature variable and one other climate variable, while controlling for latitude. One set to be investigated involved variables they anticipated would be related; the other set involved variables which they believed to be unrelated. Feedback focused on knowledge outcomes and the need to control variables. The final activity was a quiz in which students had to find out if elevation and temperature are related by controlling for distance to large bodies of water (inland or shoreline locations). The quiz was individually marked; feedback focused on the need to control variables.

Sample

Representatives from four boards identified 12 grade 7 teachers willing to field test a correlational reasoning module in their classes. Treatment teachers were asked to attend a half day workshop at the outset of the field test, administer a battery of tests to students, complete a short questionnaire, teach the module (requiring six hours of class time) within a six week timeframe, and attend a two hour feedback session at the end of the field test. None of the field test teachers had taught correlational reasoning before. Participation in the project was voluntary and teachers in both groups were told they could withdraw at any time. The treatment group teachers were matched in a quasi-experimental design with a no-treatment control group who were asked to administer a battery of tests to students and complete a short questionnaire.

Instruments

Student achievement was measured with two forms of the correlational reasoning instruments developed in Phase I. Half of the students received the medicine item as the pretest followed by the swimming item as the postest; for the remainder the order was reversed. A random sample of half the student responses were selected; if there were less than 20 complete data sets in the class, 10 were randomly chosen. The responses were coded by a single trained testor using the scheme in Figure 8. Two random samples of items were independently coded by one of the principal investigators; the proportion of exact agreement with the trained testor on the first set was 88% (42 out of 48 decisions); on the second set it was 92% (22 out of 24 decisions). Additional random samples were independently coded by experienced teachers. The proportion of exact agreement between each teacher and the trained testor averaged 81% over 236 decisions.

Teacher efficacy was measured with a 16 item self-report behavioural rating scheme developed by Gibson & Dembo (1984), contained in Appendix 4. The instrument produces an overall score and two subscores: personal teaching efficacy which reflects the teacher's sense of personal responsibility for student learning, and teaching efficacy which reflects the teacher's belief that his or her ability to bring about change is limited by factors beyond the teacher's control. Gibson & Dembo provide evidence of construct validity and of internal reliability; (the alphas for the subscales were .78 and .75). Previous researchers have found that teacher

efficacy, measured in various ways, is related to teacher attitudes (Evans & Tribble, 1986; Glickman & Tamashiro, 1982; Haury, 1989; Ingvarson & Mackenzie, 1988), to instructional practices (Poole & Okeafor, 1989; Smylie, 1988; Stein & Wang, 1988) and to student achievement (Anderson, Greene, & Loewen, 1988; Ashton & Webb, 1986; McLaughlin & Marsh, 1978; Miskel, McDonald & Bloom, 1983; Rosenholtz, 1989; Ross, 1990).

There were two measures of students cognitive styles. These were randomly assigned to teachers so that each class completed only one of the instruments. *Locus of control* was measured by a 23 item forced-choice self-report instrument (Rotter, 1966). Respondents were required to select from pairs of statements, one representing internal control (the belief that events largely result from forces within one's control) and the other representing external control (the belief that events largely result from forces beyond one's control). Evidence of the reliability and validity of the instrument has been provided by Joe (1971) and Rotter (1966). Previous researchers have found that locus of control is consistently associated with student achievement; see Lefcourt (1976) for a review.

Student *field dependence/independence* was measured by the Group Embedded Figures Test - GEFT (Witkin et al., 1971). Students were asked to recognize a simple form within a more complex structure, while being prevented from seeing both at the same time. After seven practice items, students were given five minutes to complete nine items and another five minutes to complete the final nine items. Evidence in support of the validity and reliability of the instrument has been provided by (Witkin et al., 1977). Previous researchers have found that GEFT scores are strongly linked to cognitive skills achievement (Case, 1974; Lawson, 1976; Ronning, McCurdy & Ballinger, 1984; Ross & Robinson, 1987) and interact with problem solving instruction (Ross, in press; Shymansky & Yore, 1980; Strawitz, 1984). The learning style instruments are in Appendices 5 and 6.

Procedure

After sample selection, teachers in the treatment group were given a half day in-service designed to motivate teachers to use the module and to assist teachers in its implementation. Motivation consisted of directing attention to the prominence assigned to correlational reasoning in the Ministry Guideline, identifying examples of correlational problems in Geography and in other grade 7 subjects and by demonstrating the special place of correlational reasoning in everyday life. An overview of the module was provided and the procedure for finding a correlation was demonstrated. Teachers worked through selected exercises from the three components of the module: pairs of teachers completed each task, then shared with the other teacher pair in their small group. Small group discussions were guided by a group leader who was a teacher member of the module development team. Small groups were encouraged to anticipate problems they might encounter in teaching the module and to share these in small and large group discussion. Data collection procedures were described and materials distributed. Teachers were encouraged to contact their team leaders if they encountered difficulty.

Immediately following the in-service, treatment and control teachers each administered the cognitive styles instrument they had been assigned, followed by the student achievement pretest. While students were completing the pretest the teacher filled out the teacher efficacy questionnaire. If teachers taught more than one class of grade 7 Geography, they randomly selected one class for the data collection. Treatment teachers taught the module in a six hour time period of their choosing within a six week timeframe. Halfway through the implementation they were contacted by one of the teacher members of the development team to address any problems that had arisen. Teachers could also initiate contacts with the teacher or researcher members of the development team. At the end of the six weeks, treatment and control teachers administered the postest. Treatment teachers then attended a two hour debriefing session in which they described, in small groups, the implementation of the module and provided suggestions for improving it.

During the feedback session the teachers were very positive about their experiences with the module and reported high levels of student engagement. Most experienced time problems for two reasons: (a) Most teachers had only two periods of Geography per week so

that the timeline was very tight. But the majority were still finishing up an earlier topic and did not start climate until later in the time period allotted for the field test. (b) A large number of teachers used all the exercises in the module rather than selecting from them as recommended; the reason offered was that students enjoyed doing them. Several teachers reported that they taught Lesson 1, which addressed real life examples, in other subjects (science, math or English) but this option was not available to those who taught geography on rotary. Teachers who did not complete the module were given an extension of three weeks; they were then asked to administer the posttest even if not finished. Teachers also made a number of suggestions for improvement and there was an extended discussion regarding whether Lesson 3 on controlling variables was a realistic goal for grade 7.

Analysis

In the first phase of the analysis, descriptive statistics (means, standard deviations, etc.) were computed for all the variables in the study. In order to test for main effects and interactions, hierarchical regression models were developed (Pedhazur, 1982). These models were run for the total score and each of the four skills (organizing, locating, synthesizing or concluding). PRETEST scores (covariate), treatment condition (TREATMENT: treatment or control), learning style (LSTYLE: score on the GEFT) and test order (ORDER: swimming item as pretest followed by medicine item as posttest or the opposite sequence), and the appropriate interaction terms (TREATMENT X LSTYLE, TREATMENT X ORDER, LSTYLE X ORDER, TREATMENT X LSTYLE X ORDER) were entered sequentially into the nested regression models. Treatment condition and test order were dummy variables. (Sex was not entered into the equation as an independent variable because sex did not correlate with any of the other variables in the study.) The hierarchical regression models were repeated with locus of control substituted for the GEFT as the learning style variable. This procedure permits one to calculate F ratios for all main effects and interactions. These results can be presented in an analysis of variance source table along with appropriate error terms. Adjusted means can also be calculated. As an analysis of covariance, this procedure assumed homogeneity of regression (Pedhazur, 1982). To test this assumption, the interaction of pretest scores with each of the main effects was examined--none of these tests yielded significant results, indicating that the assumption had been satisfied.

In the second phase of the analysis, student achievement data were aggregated to the teacher level. The hierarchical model regression procedure was applied once again. PRETEST scores (covariate), TREATMENT, TEACHER EFFICACY (scores on the total instrument) and the interaction term (TREATMENT X EFFICACY) were entered sequentially into the hierarchical series of regression equations. The integrated series of models was applied to each of the two teacher efficacy subscales (personal teaching efficacy and teaching efficacy).

Results

Phase I: The means and standard deviations for the key student variables are displayed in Table 2. The table shows that the classes of the treatment group were larger (by 23% overall) than those in the control. Table 2 also shows that pretest performance was extremely low on all skills with a large number of students receiving zero, especially on the skills of organizing and synthesizing information. Regression assumptions of multivariate normality were brought into serious question. Results should be interpreted with caution. The posttest scores were much higher for the treatment group but not for the control. The posttest mean for the treatment condition reached 83% and 90% of the maximum scores for locating and synthesizing information respectively, but students obtained only 56% and 45% of the maximum possible for organizing information and concluding.

Table 2 About Here

Table 3 reports the correlations between the student variables. Table 3 shows that treatment condition was significantly associated with all posttest scores, but the correlation with pretest scores was virtually zero. Neither of the learning styles measures was associated with any of the achievement variables, although the learning styles measures were themselves positively correlated. Student sex was not associated with any other variable. Students in the

control group were slightly more field independent than treatment group students. There was a strong negative correlation between test order and one of the pretest scores (synthesizing).

Table 3 About Here

Table 4 shows the source table derived from the hierarchical series of regression analyses using GEFT (field dependence/independence) as the learning style variable. The table provides the full model for the variables that predict the total achievement posttest score. Table 5 presents the source table for the full model when locus of control was substituted as the learning style variable. In both cases only treatment condition predicted total achievement; students of teachers who used the correlational reasoning module significantly outperformed students in the control condition. Contrary to expectation, neither of the learning styles measures had an effect on student learning. There were no statistically significant interactions. Pretest scores did not predict post peformance because of floor effects for the pretest scores, as shown in Table 2.

Tables 4 and 5 About Here

The subskill models (i.e., the variables that predict posttest performance on each of the four achievement measures) produced very similar results. In every case treatment students learned significantly more than control students. There were two different findings. When the GEFT was used, pretest scores were a significant predictor of students' ability to locate appropriate information [$F(1, 157) = 5.88$, $p<.016$]. The same result was obtained when locus of control was substituted [$F(1, 117) = 26.40$, $p<.001$]. Students who used more cases in responding to a correlational problem in the pretest also used more cases on the posttest. Students found this dimension of correlational reasoning considerably easier than the others; hence, the floor effect that was shown in the pretest scores for the total score analyses was not apparent for analyses involving the locating skill. The second different finding was that there was a main effect of test order for the skill of drawing a conclusion [$F(1, 154) = 11.74$, $p<.01$; $F(1, 114) = 12.87$, $p<.01$]. This main effect was found for analyses involving both the GEFT and locus of control. Students who had the medicine item as the pretest followed by the swimming item as the posttest, outperformed students who received the tests in the opposite order. The medicine item produced a conclusion that was counter-intuitive for virtually all students: very few anticipated that the number of flu cases would increase as the amount of medicine was increased. In contrast, the swimming item was less contradictory for the sample as a whole: some students expected that shorter people would swim faster; others expected the opposite. The result was that for the concluding portion of the task the medicine/swimming order was an easy to hard sequence of tests; the opposite order was a hard to easy sequence.

Figure 11 displays the adjusted post test means. The means, with one exception, were calculated using the full model. Pretest scores were excluded from the analyses on synthesizing information using the locus of control because all students received the same score (zero).

Figure 11 About Here

Phase 2: An hierarchical series of regression models was constructed with mean posttest performance (total score), aggregated to the teacher, as the dependent variable. In this analysis there were only 23 cases as one of the teachers did not complete the teacher efficacy instrument. Table 6 displays the results when teacher efficacy (the sum of all the items in the teacher efficacy instrument) was entered into the equation. The table shows that there was a main effect for treatment condition but not for teacher efficacy. The interaction was not significant. The same results were obtained when the four correlational reasoning skills each served as criterion variables, and when the models were repeated using each of the teacher efficacy subscales (personal teaching efficacy and teaching efficacy).

Table 6 About Here

Discussion

The first finding concerns instrumentation. The two measures of correlational reasoning that were used here discriminated between instructed and uninstructed students, an indicator of test validity. The inter-rater reliability of the instruments used in this phase of the project was higher than in earlier phases, particularly for agreement between a trained tester and one of the principal investgators. Even so, the level reached (89%) was still below the levels of agreement recorded with other problem solving instruments (low to high 90's).

The tests were extremely difficult; large numbers of students scored zero on one or more of the skills prior to instruction. With the pretest scores skewed toward zero, assumptions of normality required for regression analysis were violated. The simplest solution would be to standardize the existing scores using logarithmic transformations, although this would take us another step away from the original data. A better strategy might be to decompose the lowest level of the growth profile for each skill to make distinctions within the zero category. The revised scheme could then be used to re-analyze the responses. The best strategy might be to use a simpler measure as the pretest. For example, even young students are able to generate a response to the 2 X 2 contingency table tasks developed by Piaget and elaborated by Shaklee & Mims (1981).

The second finding is that the instructional treatment had a large positive effect on students. The overall effect size, using the formula of Glass, McGaw & Smith (1981), was 3.64, meaning that the average student in the treatment condition outperformed 99% of the students in the control. Student learning was not evenly distributed across the skills: performance increased to almost the maximum of the scale on two of the skills (locating and synthesizing) but the mean reached only the mid-point for the other two skills. One of these skills, organizing information, involves mastery of the controlling variables schema, a notoriously difficult objective for teachers and students (Ross, 1988c). The other skill, concluding, may be more amenable to instruction. In the treatment delivered in this study, concluding was given less overt attention; students essentially learned by imitating the examples of appropriate conclusions provided in feedback to the exercises. A better strategy would to explicitly demonstrate how to conclude and to give more emphasis to this dimension of correlational reasoning in feedback to students and in the design of in-service for teachers. In addition, drawing a conclusion is best undertaken in the context of a specific hypothesis. Students' concluding skill might be enhanced by including instruction on predicting, a skill that was omitted from the treatment delivered in this study.

The third finding is that student performance was not affected by the two learning styles examined. The failure of these learning styles to correlate with pretest performance may be attributable to the previously described floor effects that constrained the predictive power of pretest scores. But learning styles did not correlate with posttest scores either, nor did student learning styles mediate instruction. The instructional treatment was equally effective with field dependent as with field independent students, regardless of whether the student's locus of control was external or internal. In a sense this is good news; the program designer need not be concerned with accommodating aptitude treatment interactions for these aptitudes. But, of course, other student variables, e.g., measures of fluid and crystallized ability, could have an effect and further research is required to examine these possibilities.

The last finding is that teacher efficacy had no effect on student learning. The most likely explanation for this unexpected finding is small sample size.

Next Steps in the Correlational Reasoning Project

The next priority in the project is to replicate the grade 7 instructional experiment with a similar set of materials developed for the grade 9/10 Geography course, contained in Appendix 7. These materials are similar in format to the grade 7 material but they incorporate suggestions from the grade 7 pilot test teachers. The grade 9/10 materials are currently being reviewed by small groups of teachers and will be pilot tested in the fall of 1990. The research design will be similar to the grade 7 pilot, but it is anticipated that the pretest will be changed

to a less difficult instrument and that the learning styles instruments will be deleted or replaced with a different set of measures.

In Phase III, scheduled to begin in the fall in 1990, the grade 7 materials will be field tested in two different teaching modes. In the whole class method the approach will be highly teacher centred with demonstration and interactive lessons followed by individual seat work. In the cooperative learning method there will be demonstration and interactive lessons, but the practice activities will be undertaken in small groups using a combination of individual and group rewards. Small group interactions will be recorded in one or two classrooms. The comparison of whole class and cooperative learning approaches will continue in January 1991 with the field test of the grade 9/10 materials.

In Phase IV a computer assisted version of correlational reasoning instruction will be developed. Preliminary work has begun toward developing appropriate software. Piloting is to begin in January of 1991 with the formal field test in September of 1991.

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FOOTNOTES

[1]In fairness to Piaget, all of the instances of these conditional probability problems provided in, for example, Shaklee & Paszek (1982) contain relationships which are not statistically significant at the $p<.05$ level, using a chi-square test.

[2]Curtis claimed that the software program outperformed the control but the raw data he provided (1985: 102-3) indicate that the effect size of the software program was -.13.

TABLE 1

STUDIES OF CORRELATIONAL REASONING

Study	Sample	Instrument	Number of Variables	Type of Variables	Definition of Growth	Skills Addressed
Adi et al. (1978)	n=80, gr.9 & 12	interview	two	dichotomous	levels	obtain and process data
*Curtis (1985)	n=108 undergrads, 31 grads, 16 faculty	open ended	two	continuous	levels	process data
Inhelder & Piaget (1958)	not reported	interview	two	dichotomous	levels	process data
Koslowski & Okagaki (1986)	n=32, gr.6, 9 & university	multiple choice	five	dichotomous independent variables, continuous dependent variables	criterion	predict
Kuhn & Brannock (1977)	n=80, gr.4,5,6, university	interview	four	dichotomous	levels	frame data
Kuhn & Ho (1977)	n=100, gr.4,6,8, 12, university	interview	three	nominal	levels	process data
Lavoie & Good (1988)	n=14, age 15-18	interview	seven	continuous	levels	predict
McKenzie & Padilla (1986)	n=69, gr.7-12	multiple choice	two	continuous	criterion	process data
*Popp, Robinson & & Fast (1975)	n=33, gr.6	not reported	three	continuous	criterion	frame and process data
*Prentice (forthcoming)	TBA	open ended	two	continuous	criterion	predict, frame & process data
Robinson et al. (1985)	n=35, gr.4,6,8, 10, adult	interview	two	continuous	levels	process data

Table 1 (continued)

Study	Sample	Instrument	Number of Variables	Type of Variables	Definition of Growth	Skills Addressed
Ross & Maynes (1981)	n=1680, gr.7 & 10	multiple choice	two	continuous	levels	predict and process data
*Ross & Maynes (1983a)	n=551, gr.7,8,10	multiple choice	three	continuous	levels	frame and process data
*Rowell & Dawson (1984, 1985)	n=44, gr.8	open ended	four	dichotomous	criterion	process data
*Shaklee, Hall & Paszek (1982)	n=36, 7-year olds	not reported	two	dichotomous	levels	process data
Shaklee & Mims (1981)	n=103, gr.4,7,10, college	multiple choice	two	dichotomous	levels	process data
*Shaklee & Paszek (1981)	n=72, gr.1-4	interview	two	dichotomous	levels	process data
Wavering (1984)	n=94, gr.8,10,12	interview	two	dichotomous	levels	process data
Wavering (1989)	n=150, gr.7-12	open ended	two	continuous	levels	process data

TABLE 2

MEANS AND STANDARD DEVIATIONS FOR CORRELATIONAL REASONING SKILLS

	Treatment (n=152)		Control (n=126)		Maximum Score
	Pre	Post	Pre	Post	
Achievement					
Total	1.57 (1.37)	7.86 (2.80)	1.43 (1.27)	1.94 (1.73)	12
.organize	0.25 (0.13)	2.25 (2.28)	0.20 (0.11)	0.38 (0.27)	4
.locate	0.49 (0.75)	1.79 (1.88)	0.46 (0.79)	0.69 (0.66)	2
.synthesize	0.10 (0.01)	2.48 (0.99)	0.04 (0.27)	0.21 (0.60)	3
.conclude	0.73 (0.89)	1.34 (0.98)	0.72 (0.89)	0.67 (0.63)	3
Learning Styles					
.GEFT	6.97 (4.44) (n=91)		10.68 (5.02) (n=68)		18
.locus of control	9.71 (2.81) (n=61)		11.40 (3.49) (n=58)		23

TABLE 3

CORRELATION OF TREATMENT CONDITION, LEARNING STYLES, SEX, TEST ORDER AND ACHIEVEMENT

	Treatment	GEFT	Locus	Sex	Order
GEFT	20*				
Locus	12	77**			
Sex	-03	-06	-03		
Test Order	02	-02	01	05	
Total Post	76**	-15	-13	09	03
Post Organize	68**	-07	-09	09	-05
Post Locate	60**	-16	-13	10	00
Post Synthesize	81**	-18	-16	05	03
Post Conclude	34**	-08	-03	06	22
Total Pre	03	00	00	07	-26
Pre Organize	04	-05	-09	08	-11
Pre Locate	02	-02	-03	07	-07
Pre Synthesize	08	-14	-16	-04	-42**
Pre Conclude	01	07	11	05	00

*$p<.05$ **$p<.001$

TABLE 4

SOURCE TABLE FROM REGRESSION ANALYSIS:
GEFT AS LEARNING STYLE VARIABLE

PREDICTOR	SS	df	MS	F	p<
1. PRETEST	2203.42	1	9.98	0.71	ns
Error	2203.42	157	14.03		
2. TREATMENT	1142.74	1	1142.74	168.05	.001
Error	1060.68	156	6.80		
3. LSTYLE	6.84	1	6.84	1.01	ns
Error	1053.84	155	6.80		
4. ORDER	6.51	1	6.51	0.96	ns
Error	1047.33	154	6.80		
5. TREATMENT X LSTYLE	11.72	1	11.72	1.73	ns
Error	1035.61	153	6.77		
6. TREATMENT X ORDER	2.68	1	2.68	0.39	ns
Error	1032.93	152	6.80		
7. LSTYLE X ORDER	0.22	1	0.22	0.03	ns
Error	1032.71	151	6.84		
8. TREATMENT X LSTYLE X ORDER	1.02	1	1.02	0.15	ns
Error	1031.69	150	6.88		

Adjusted Means: Treatment = 7.29; Control = 2.68

TABLE 5

SOURCE TABLE FROM REGRESSION ANALYSIS:
LOCUS OF CONTROL AS LEARNING STYLE VARIABLE

PREDICTOR	SS	df	MS	F	p<
1. PRETEST	1931.36	1	40.57	2.46	ns
Error	1931.36	117	16.51		
2. TREATMENT	1294.83	1	1294.83	116.98	.001
Error	636.53	116	5.49		
3. LSTYLE	0.03	1	0.03	0.00	ns
Error	636.50	115	5.53		
4. ORDER	16.57	1	16.57	3.05	ns
Error	619.93	114	5.44		
5. TREATMENT X LSTYLE	3.80	1	3.80	0.70	ns
Error	616.13	113	5.45		
6. TREATMENT X ORDER	6.02	1	6.02	1.10	ns
Error	610.11	112	5.45		
7. LSTYLE X ORDER	2.83	1	2.83	0.52	ns
Error	607.28	111	5.47		
8. TREATMENT X LSTYLE X ORDER	0.36	1	0.36	0.07	ns
Error	606.92	110	5.52		

Adjusted Means: Treatment = 9.74; Control = 1.82

TABLE 6

SOURCE TABLE FROM FULL REGRESSION MODEL:
TEACHER AND STUDENT DATA

PREDICTOR	SS	df	MS	F	p<
1. Pretest	246.08	1	0.45	0.04	ns
Error	246.08	22	11.19		
2. Treatment	193.35	2	193.35	77.03	.001
Error	52.73	21	2.51		
3. Teacher Efficacy	0.03	3	0.03	0.01	ns
Error	52.70	20	2.64		
4. Efficacy X Treatment	4.95	4	4.95	1.97	ns
Error	47.76	19	2.51		

Adjusted Means: Treatment = 25.53; Control = 11.83

ORGANIZING SKILL

Arranging Data	Control Variable	Data Display
-no rearrangement (e.g., recopy data as found in the chart)	-no controls	-none
-irrelevant arrangement [e.g., calculate the average age & average distance for the whole sample (13-15)]	*-separating the data for only one value of a control variable (e.g., boys only)*	-concrete picture [e.g., Figure X (4-2)] -tabular display [e.g., Figure 3 (7-1)]
-ordering from highest to lowest cases using one variable (e.g., 7-4) -ordering from highest to lowest cases using two variables (e.g., u-6)	-separating the data into more than one value of the control variable [e.g., the relationship for boys and then the relationship for girls (u-6)]	-bar graphs/line graphs [e.g., Figure 4 (u-10)] -scatter plots [e.g., Figure 5 (u-6)] -scatter plots with "best fit" line [e.g., Figure for males (u-6)]
NOTE: Most organized the cause variable but the effect variable could be equally well used. (Possibly ordering on the effect variable would be better.)		

Figure 1: Example of Multi-Strand Growth Scheme

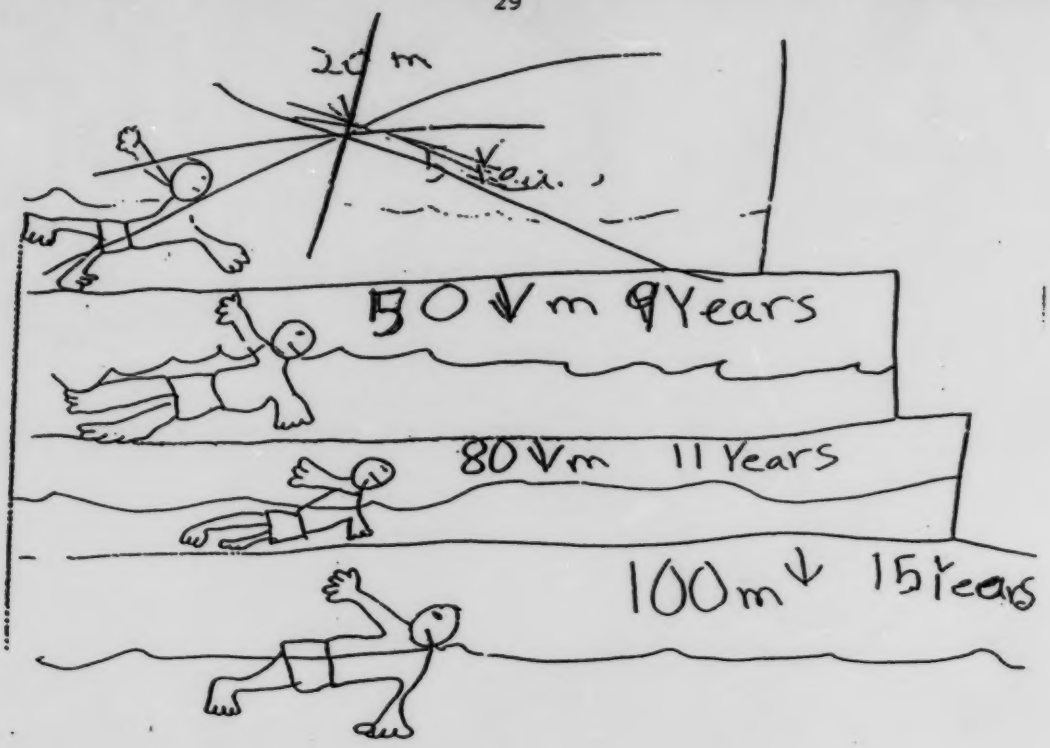


FIGURE 2: CONCRETE PICTURE

girls			boys		
number	age	length	number	age	length
1	10	47m	2	10	45m. 49 m.
2	11	48 m. 43 m.	1	11	79 m.
2	12	48 m. 70 m.	2	12	40 m. 86 m.
2	13	82 m. 41 m.	2	13	84 m. 95 m.
1	14	66 m.	1	14	99 m.
			1	15	101 m.

FIGURE 3: TABULAR DISPLAY

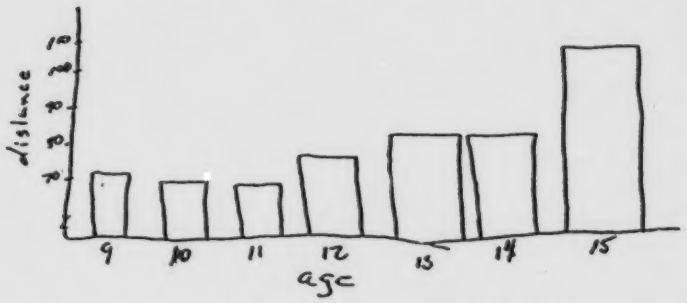


FIGURE 4: BAR GRAPH

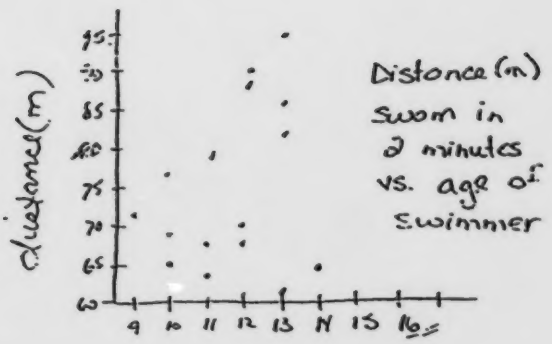


FIGURE 5: SCATTER PLOTS

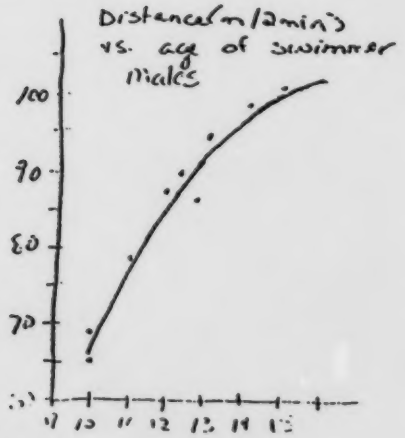


FIGURE 6: SCATTER PLOTS WITH "BEST FIT" LINE

GROWTH IN ORGANIZING A CORRELATIONAL PROBLEM

To organize a correlational problem is to arrange the information in a structure that makes it possible to find relationships between variables.

1. No Productive Display

   - the student does not rearrange the data or does so in an unproductive way; (e.g., the student might calculate the average of all the swimmers and the average distance swum by the whole group) or the student might draw a picture showing the superficial features of the problem (e.g., a picture of some students swimming)

2. Ordering on One Variable

   - the cases are arranged from lowest to highest on one variable; e.g., a table listing the swimmers from youngest to oldest; the table could also contain groups of swimmers rather than individual cases

3. Ordering on Two Variables

   - the cases are arranged from low to highest on both variables; e.g., in a line graph, a scatter plot or a bar graph ordered horizontally as well as vertically [Grade 7-8 Goal]

4. Displays Exposing the Influence of Control Variables

   - the cases are arranged to expose the influence of a control variable on the relationship; e.g., a graph of age and swimming distance containing a trend line for girls and another line for boys [Grade 9-10 Goal]

Figure 7: Example of Single Strand Growth Scheme

FIGURE 8:

MARKING SCHEME FOR CORRELATIONAL SKILLS

1. ORGANIZING INFORMATION

(a) Did the student have no productive display (i.e., no rearrangement of the data)?	0 marks
(b) Did the student have a display in which the data were rearranged from lowest to highest on 1 variable?	1 mark
(c) Did the student have a graph in which the data were rearranged simultaneously from lowest to highest on 2 variables?	2 marks
(d) Did the student have a display with the data rearranged from lowest to highest on one variable, and a control variable?	3 marks
(e) Did the student have a graph with the data rearranged from lowest to highest on 2 variables, and a control variable?	4 marks

2. LOCATING OR SELECTING DATA

(a) Did the student randomly (or unsystematically) select a few (e.g., 3 to 4) cases?	0 marks
(b) Did the student systematically select a few (e.g., 3 to 4) strategic cases?	1 mark
(c) Did the student select enough cases (12 or more) to make a decision as to whether or not there is a relationship?	2 marks

3. SYNTHESIZING INFORMATION

(a) Did the student make no attempt to summarize?	0 marks
(b) Did the student use a simple summary strategy (e.g., averages)?	1 mark
(c) Did the student put the data in a graph, without a trend line?	2 marks
(d) Did the student use a nontechnical way to represent the trend (e.g., draw a trend line on a graph)?	3 marks

4. DRAWING A CONCLUSION

(a) Did the student fail to describe a correct relationship?	0 marks
(b) Did the student describe a partially correct relationship? (e.g., if the student controlled variables, one relationship is correct as shown in part d; or, e.g., if variables are not controlled, a relationship that is correct only if unusual cases are ignored; i.e., height is negatively related to swimming; medicine increases flu)	1 mark
(c) Did the student describe a correct 2 variable relationship? (e.g., height and swimming are not related or, e.g., medicine and flu cases are not related)	2 marks
(d) Did the student describe a correct 3 variable relationship? (e.g., height is negatively related to swimming for girls and height is not related to swimming for boys; or, e.g., medicine is positively related to the flu for the pill and medicine is not related to the flu for the needle)	3 marks

(i) Make a graph

.draw the two axes

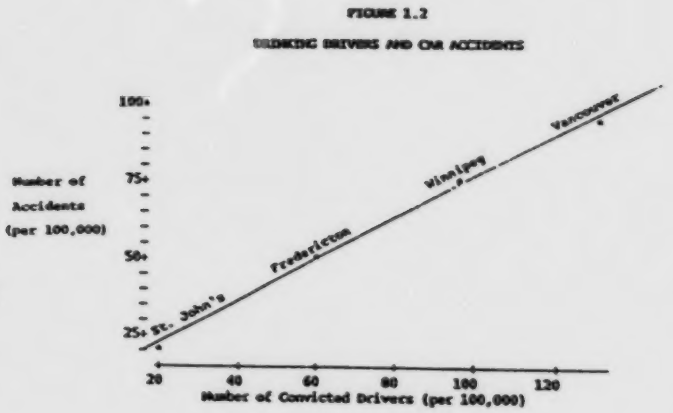
.give each axis a name

.put in a scale for the horizontal axis: begin with the lowest score and end with the highest

.divide the scale into units

.put in the vertical scale

.give the graph a title



(ii) Put information in the graph

.locate the first case on the horizontal; run a ruler straight up

.locate the first case on the vertical; run a ruler straight across

.place a small mark where the rulers intersect

.repeat for the rest of the cases

(iii) Read the graph

.draw a line that comes as close to each case as possible

.decide the kind of correlation

Figure 9: How to Find a Correlation

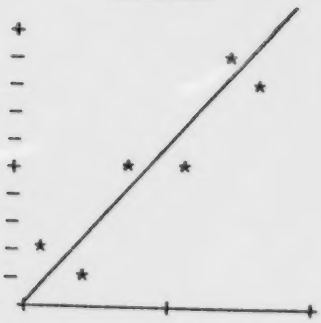
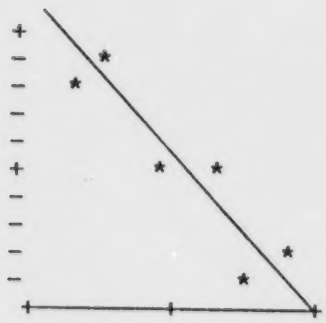
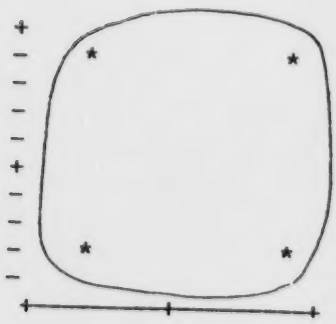
Type	Example	Definition
Positive Correlation		as one thing changes, the other changes in the same way
Negative Correlation		as one thing changes, the other changes in the opposite way
Non Correlation		as one thing changes, there is no pattern in the other factor

Figure 10: Types of Correlations

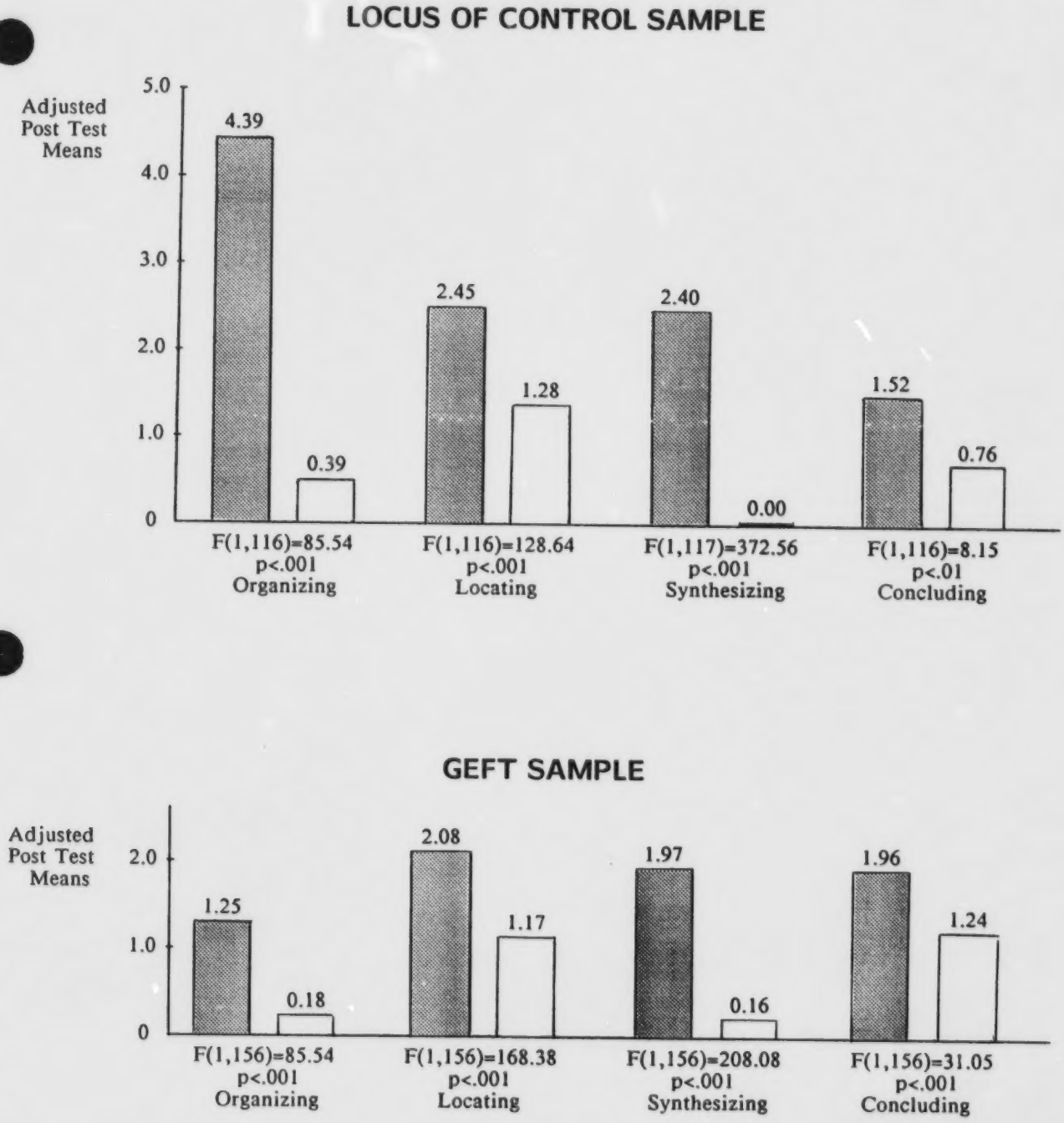


Figure 11: Adjusted Means from Partial Models

APPENDIX

Special Section: Guideline Implementation

Editor's Note: The following two articles are being featured in The Monograph as part of O.A.G.E.E.'s efforts to help geographers implement the new Ministry of Education guidelines released in September, 1988. Future issues will include other reports and articles dealing with implementation issues. Members are encouraged to share their ideas and successes in implementation by contributing articles for inclusion in this continuing series of special sections in The Monograph.

STUDENT DEVELOPMENT OF CORRELATIONAL REASONING SKILLS: PRELIMINARY FINDINGS

John A. Ross and J. Bradley Cousins, O.I.S.E. Trent Valley Centre

One of the challenges of the Intermediate/Senior Geography Guideline is the requirement that students develop sophisticated correlational reasoning skills. How close are students to meeting these expectations? This article provides preliminary information for unit writers prior to Guideline implementation.

Measuring Correlational Skills

In phase I of the study, a simple correlational task was administered to convenience samples of 20 students in each of grades 4, 7, 9, OAC and third year Honours Geography. Students were given the data contained in Table 1 and were asked to find out if swimming was related to age, using only the information in the table. Take a few moments to try this task yourself: it's harder than it looks.

A team of researchers[1] searched the 100 responses to find common themes. A large classification scheme containing many dimensions was developed and then simplified to highlight the most commonly occurring types.

In phase II of the investigation, a slightly revised version of the first task was given to half the students in a new sample; the remainder received a very similar task involving skating and hockey players. The responses from the 120 students in the new sample (20 students in each of grades 5, 7, 9, 11, OAC and M.Ed.) were analyzed using the simplified scheme developed in phase I. Only slight revisions were required.

Results

The first pattern concerned skill in **organizing information.** Four levels emerged from the responses. The average scores of students in each grade are shown in Table 2.

1. **No productive display.** Students at this level did not rearrange the data at all or organize it in a way that made it difficult to find patterns. For example, some students calculated the average age of all the swimmers and then worked out the average distance swum by the whole group. Some of the younger students drew pictures showing swimmers.

2. **Ordering on one variable.** Students re-arranged the data from lowest to highest on one variable (usually age). The resulting table showed that as age increased there was a similar increase in swimming speed.

3. **Ordering on two variables.** These students produced a line graph or scatter plot in which the cases were arranged from lowest to highest on both variables. The graph showed a positive relationship: swimming speed increased with age. These students were meeting the Guideline expectation for the end of grade 9/10.[2]

4. **Displays exposing the influence of control variables.** These students produced two graphs (or two lines on a single graph) that demonstrated the influence of sex on swimming speed. The graphs showed that there was a very strong relationship between swimming speed and age for boys; for girls the variables were unrelated. These students met the Guideline expectation for the end of the Senior Division.

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[1] The research team consisted of George Janota (Hastings County Board of Education), John Martyn (Peterborough-Victoria-Northumberland and Newcastle Roman Catholic Separate School Board), Trudy Nisbett (Peterborough County Board of Education), Gary Quinlan (Northumberland and Newcastle County Board of Education), as well as Anne Hogaboam and the authors (Ontario Institute for Studies in Education)

[2] Intermediate/Senior Geography Guideline, 1988, Part B, p. 23

Table 1: Raw Data for Correlational Task

Mrs. Campbell, the swimming coach, tests the swimming team every week. Here are the results from last Saturday (distance in 2 minutes):

NAMES	SEX	AGE (years)	DISTANCE (metres in 2 minutes)
Sue	girl	10	77 m
Mike	boy	13	95 m
Colin	boy	12	90 m
Judy	girl	13	82 m
Mel	boy	10	65 m
Patrick	boy	14	99 m
Janice	girl	11	68 m
Jeff	boy	12	88 m
Carolyn	girl	11	63 m
April	girl	14	65 m
Cathy	girl	12	68 m
Helen	girl	13	61 m
Bob	boy	11	79 m
Lincoln	boy	10	69 m
Karen	girl	9	71 m
Sarah	girl	12	70 m
Peter	boy	15	101 m
Michael	boy	13	86 m

Table 2: Average Scores in Correlational Reasoning, by Grade

Grade	Organize	Locate	Synthesize	Conclude
Gr 5	1.05	1.85	1.00	1.95
Gr 7	1.30	3.10	1.05	2.25
Gr 9	1.80	2.70	1.45	2.55
Gr 11	2.65	3.85	1.40	3.40
O.A.C.	2.55	3.75	1.45	3.05
M.Ed	2.75	3.80	1.45	2.90

The next pattern emerging from the responses concerned the skill of **locating or selecting data.** There were also four levels of this skill but the differences between levels 2 and 3 were not easily observed.

1. **No data located.** At the lowest level students responded to the problem without referring to any of the cases given in Table 1.

2. **Random cases.** Students at this level discussed a small number of cases (or even a single case); for example, they might talk about Mike and Karen, but it was impossible to tell why these cases were selected as opposed to all the others in the table.

3. **Principled sample of cases.** These students also selected a small number of cases, but these were more useful in finding relationships. For example, the oldest and youngest swimmer might be chosen for discussion.

4. **Enough cases to find a relationship.** These students selected enough cases to find a strong relationship; for example, all 18 cases in Table 1. This is the Guideline expectation for the end of the Senior Division.

The next pattern concerned the strategy used to synthesize information. Only three levels appeared.

1. **Crude strategies.** At the lowest level students made no attempt to summarize; usually they compared individual cases.

2. **Simple summary strategies.** These students calculated simple statistics; usually they compared the average speed of all the swimmers in each age group.

3. **Nontechnical representation of the trend.** Students at this level drew a line freehand on a graph that showed the trend in the data. This is the Guideline expectation for the end of grade 9/10. At the outset of the analysis a fourth level was considered: **Technical representation of the trend;** for example, calculating a trend line using the least squares technique. None of the sample of 120 respondents in phase II did this, although there was one in the university sample of phase I who calculated a correlation coefficient.

The last pattern concerned the skill of **drawing a conclusion.** Here there were five levels .

1. **No correct relationship.** At this level students failed to describe a relationship or suggested one that was not true for the data (e.g., "girls' swimming declines with age") or a relationship that was irrelevant to the problem statement (e.g., "boys swim faster than girls").

2. **Partially correct relationship.** Students described a relationship that was correct for part of the data (e.g., "the older the boy the faster the swimming for the first 6 places").

3. **Correct two variable relationship.** At this level students described a correct relationship; for example, "swimming skills improve as you get older."

4. **Correct two variable relationship explained.** These students added an explanation for the relationship they found, using variables not included in the data; for example, "swimming skills depend on age...because age determines the strength of the body."

5. **Correct multivariate relationship.** Students who met the Guideline expectation for the Senior Division described the relationship between two variables in the context of other variables included in the data analysis; for example, "the distance [swum] increases by age in boys...distance and age in girls has no relation."

Preliminary Conclusions

Some skills develop more quickly and completely than others. Empirically, Table 2 shows that locating data is the easiest; synthesizing the most difficult. Intuitively, some skills appear to be much easier to teach than others.

Current performance is a long way from desired performance. No one in the first or second phase of the study (a total of 220 respondents, including 80 at O.A.C. or university) met the Guideline expectations for the end of the Senior Division. At each grade level the performance was below the desired levels.

Our investigation into correlational reasoning is continuing. We are particularly concerned at the moment with understanding how the skill of focusing a correlational problem develops and with the reliability of the schemes described in this article in making sense of student work. As we become better informed as to how these skills develop, we are experimenting with new instructional strategies focused directly on the expectations of the Guideline. We are optimistic that students in the Intermediate and Senior Divisions can become sophisticated geographic inquirers capable of solving correlational problems.

DIRECTIONS FOR TEST ADMINISTRATION

1. Randomly divide the class so that half the students get the swimming item and the remainder get the medicine item.

2. Give students the following directions:

> Today you are going to be asked to answer 3 short questions. Some of you will be asked about swimming and some of you will be asked about medicine.
>
> These questions can be answered in many different ways. It is not a test. Your answers will not count toward a mark for any subject. But we want you to try your best. We want to find out how you think.

3. Distribute page 1. Collect the student responses. Approximately 3 to 5 minutes will be required.

4. Distribute page 2. Tell students, **"If you need more space, use the back of the sheet."** Collect the student responses. Approximately 15 to 20 minutes will be required.

5. Please return to John Ross, OISE Trent Valley Centre, in the attached envelope by **SEPTEMBER 19, 1989.**

NAME_____ GRADE_____ SCHOOL_____

SWIMMING

QUESTION A

Are taller students faster swimmers than shorter students?

Write a sentence that says how (or if) height is related to swimming speed.

GO TO PAGE 2

Name _____

QUESTION B

Find out if there was a relationship between the height of students and how fast they swim.
Use only the information in the table. Show your work.

Mrs. Campbell, the swimming coach, tests the swimming team every week.
Here are the results from last Saturday.

Student	Sex	Height (in m)	Distance (m in 2 minutes)
Sue	girl	1.5	93
Mike	boy	1.4	85
Colin	boy	1.6	80
Judy	girl	1.8	73
Mel	boy	1.7	90
Patrick	boy	2.0	90
Janice	girl	1.5	102
Jeff	boy	1.9	80
Carolyn	girl	1.3	106
April	girl	1.9	77
Cathy	girl	1.7	88
Helen	girl	1.7	86
Bob	boy	1.3	93
Lincoln	boy	1.5	97
Karen	girl	1.6	95
Sarah	girl	1.4	97
Peter	boy	2.0	96
Michael	boy	1.8	97

QUESTION C: **Write a sentence that says how (or if) height is related to swimming speed.** _____

NAME_____ GRADE_____ SCHOOL_____

MEDICINE

QUESTION A

Some medicines keep you from getting sick. If you get a needle you may not get the flu. Does the amount of medicine you are given make a difference?

Write a sentence that says how (or if) the amount of medicine is related to whether or not you get the flu.

GO TO PAGE 2

Name _____

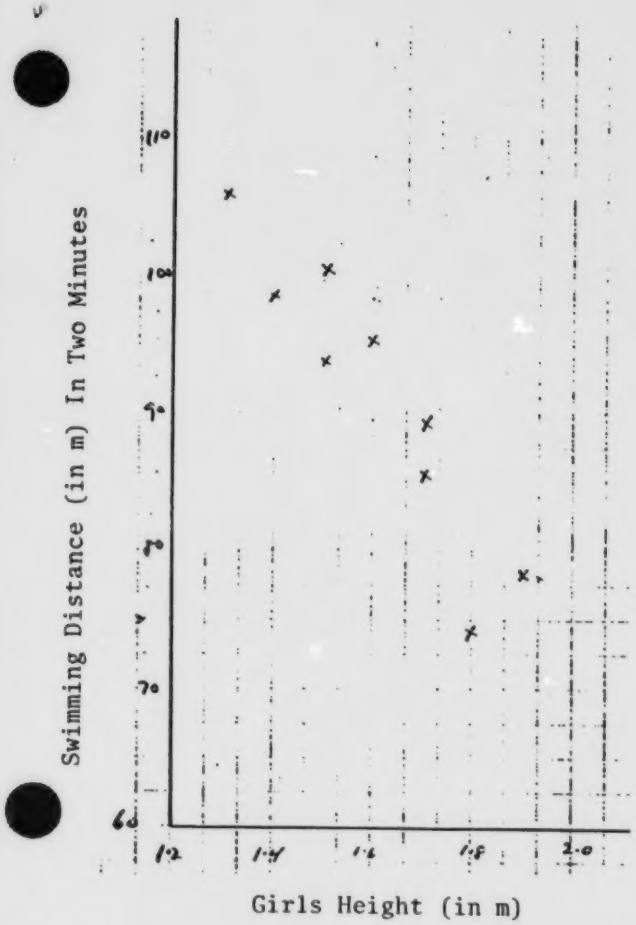
QUESTION B

Find out if there was a relationship between amount of medicine and number of cases of flu.
Use only the information in the table. Show your work.

One winter there was a lot of flu. All the students were given the same medicine to protect them from getting it. The amount of medicine given to the students was different in each school. Some students got the flu and some didn't.

School	How the Medicine was Given	Amount Given (in .00 ml)	Number of Flu Cases (per 100)
Alma	pill	0.20	14
Appleby	needle	0.28	25
Bayside	pill	0.60	16
Brant	needle	0.45	38
Central	needle	1.10	29
Churchill	pill	0.90	37
Donlands	needle	0.88	20
Drayton	pill	0.35	8
Edwards	pill	0.65	24
Elgin	pill	0.10	5
Franklin	needle	0.22	32
Frontenac	needle	0.58	18
George VI	pill	0.80	32
Halton	needle	1.10	36
Independence	needle	0.62	28
Jeffries	pill	0.45	22
Knowlton	pill	0.38	18
Lawrence	needle	0.77	37

QUESTION C: Write a sentence that says how (or if) the amount of medicine is related to whether or not you get the flu.



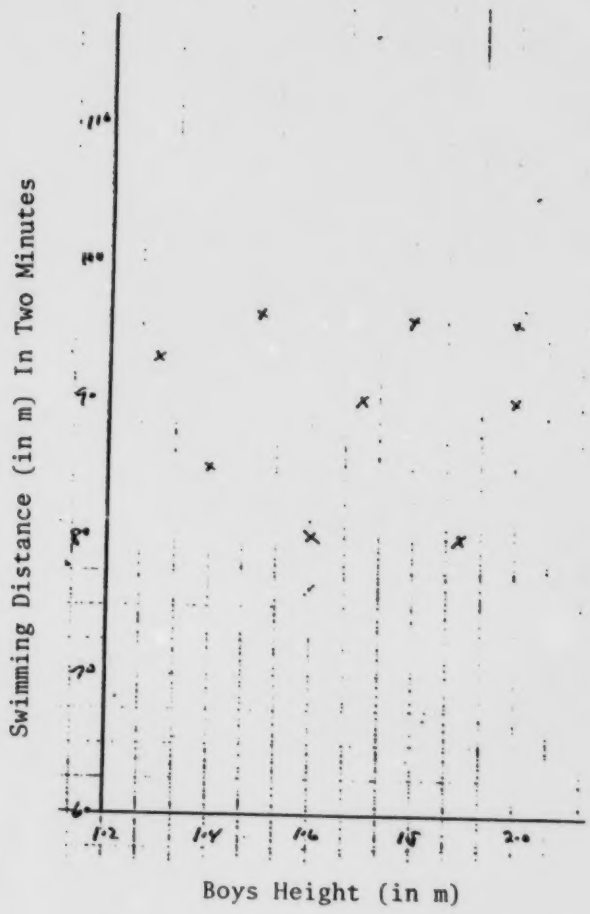
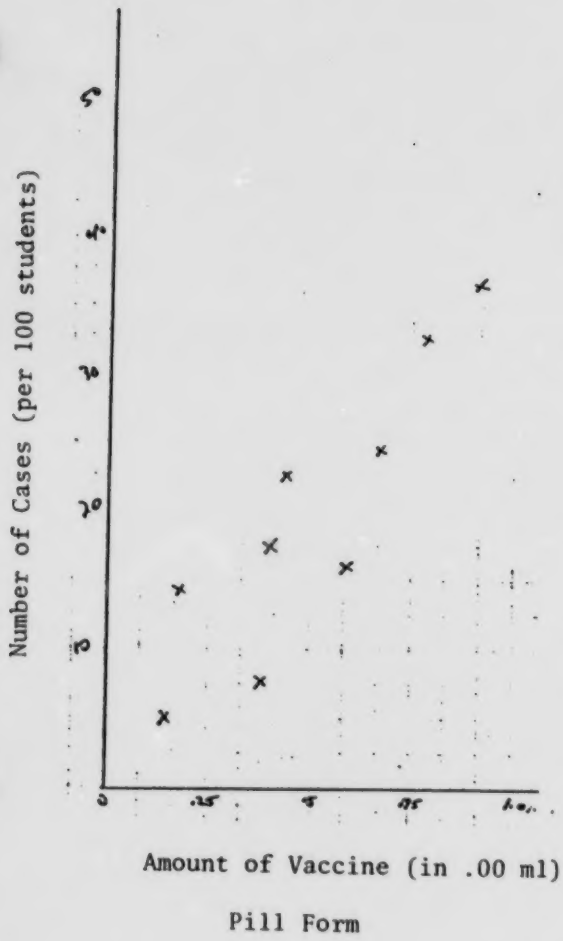


Figure: The Relationship Between Height and Swimming Speed,
For Boys and Girls



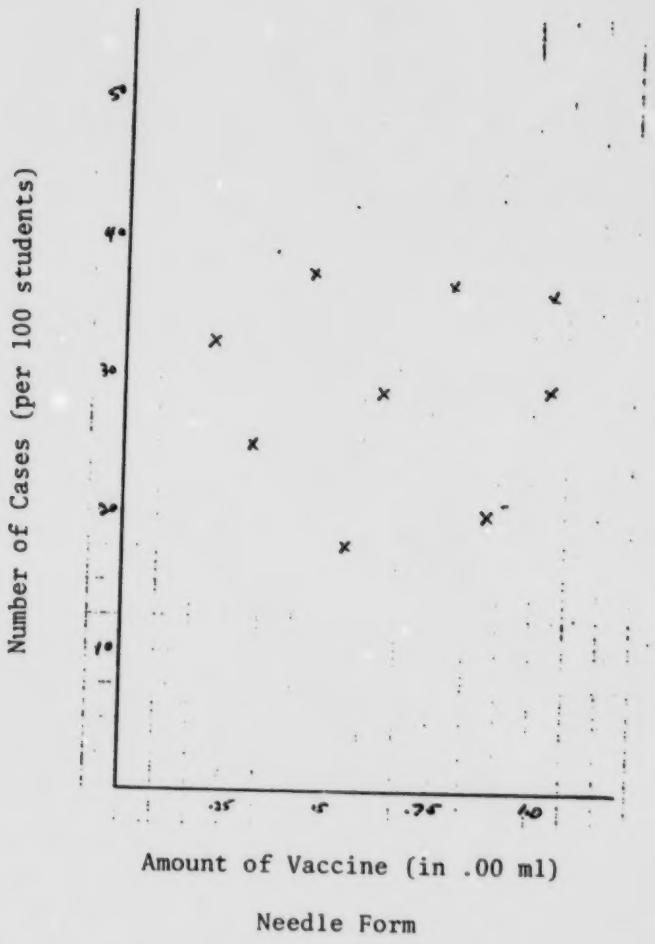


Figure: The Relationship Between the Amount of Vaccine and Flu Cases, In Pill and Needle Form

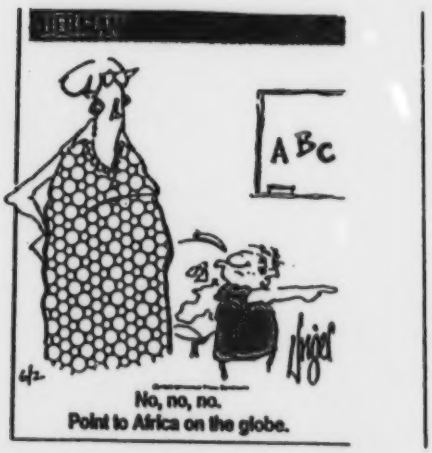
PETERBOROUGH COUNTY BOARD OF EDUCATION

CORRELATIONAL REASONING MATERIALS

"And notice, gentlemen, the faster I go, the more Simmons sounds like a motorboat."

FOR THE GRADE 7 TOPIC - CLIMATE

FIELD TEST VERSION



OCTOBER 20, 1989

CORRELATIONAL REASONING MATERIALS

FOR THE GRADE 7 TOPIC CLIMATE

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A NOTE TO TEACHERS

The Intermediate Geography Guideline places a great deal of emphasis on the development of students' correlational reasoning skills. But, the new grade 7 textbooks do not provide any materials that could be used to teach correlation. This is what this package attempts to do.

These materials are a supplement to your Grade 7 climate unit. This is NOT a complete Grade 7 unit on climate, nor is it the only topic in which the skill could be addressed. Correlational reasoning is a very important skill that applies very nicely to many other topics which are covered in the geography curriculum.

This package of materials begins with correlations in everyday life and then integrates this skill into your grade 7 geography climate unit. The climate unit was chosen because there are a number of important relationships which can be investigated by students themselves. We do not expect you to follow this package from start to finish without a break. You may choose to spend 3 classess covering Lesson 1, then spend a few days on your own climate materials before returning to our correlational reasoning materials. We expect that it will take most teachers about 10 classes to complete all three lessons in this package. We have included a number of optional activities in this package for additional practice and to raise/lower the difficulty of each exercise.

As you look through this package you will notice that we have greatly simplified correlational reasoning. This is a new skill for students at the grade 7 level and we want them to receive a firm basic understanding of the concept without overloading them. For example, we have not said anything about the convention of placing the independent variable on the horizontal axis because the graph will look the same even if the placement of the variables is reversed. Also, we have chosen not to address the notion of causality directly.

The text which appears in italics contains suggestions for questions and problems which you may wish to pose to the class. We have also included detailed ideas on how to teach the skill. We have colour-coded the pages - teacher instructions appear in the yellow pages and the student exercises appear in the white pages. A glossary of terms is included at the end of this section.

We hope that you will enjoy teaching this new skill in your grade 7 geography class. We feel that this is a very important skill for students to learn because correlational reasoning is something which we use in our day-to-day lives, both as adults and children.

This package is complete, but some teachers (not all) may wish to provide their students with graph paper.

Glossary

Correlation: Putting together two things to see if they are related. For example, if you put the number of drinking drivers in each city together with the number of traffic accidents in the same cities, you will see that as one changes, the other changes.

Positive Correlation: As one thing changes, the other changes in the same way. For example, as the number of drinking drivers goes up, the number of traffic accidents go up.

Negative Correlation: As one thing changes, the other changes in the opposite way. For example, as the distance from industry goes up, the number of lung disease cases goes down.

Non Correlation: As one thing changes, there is no pattern in the other thing. For example, as the size of cars goes up, the number of accidents goes up, down or stays the same.

Variable: Anything of interest that can change or take different values. For example, the number of drinking drivers in a city is a variable because the number is different in each city.

SUMMARY OF CORRELATIONAL SUPPLEMENT TO CLIMATE UNIT

LESSON	OBJECTIVES	TEACHING STRATEGY	RESOURCES	EVALUATION
1 (4 pds)	.To understand the concept of correlation	.provide students with motivation for learning how to solve correlational problems by discussing how they feel through the day	.use information on constructing a happiness thermometer Figure 1.1	
	.Be able to organise and interpret correlational data	.demonstrate the procedure which students should follow for making a graph, putting information into the graph and reading the graph	Table & Figure 1.2	Exercises 1.7 & 1.8
	.Be able to distinguish between positive correlations, negative correlations and non correlations in everyday problems	.demonstrate using 3 real life examples, the difference between positive, negative & non correlations	Table & Figure 1.2; Figure 1.3; Table 1.3 & Figure 1.4	
		.assign practice tasks in which students have to apply the procedure to real life examples	Exercises 1.1 to 1.8	Quiz #1
2 (2 pds)	.Be able to organize & interpret correlational data in geographic problems	.assign practice tasks in which students have to apply the procedure to geographic data (latitude and temperature)	Tables/Figures 2.1-2.6	Exercises 2.1-2.3
	.Understand the relationship between latitude & temperature	.students find the relationship between latitude & temperature and between longitude & temperature	correct answers in Figures 2.7-2.9	
3 (3-4 pds)	.Be able to control variables in a correlational problem	.asign practice tasks in which students have to apply the procedure to geographic data	Tables & Figures 3.1-3.3	Quiz #2
	.Understand the effect of elevation and nearness to large bodies of water on temperature	.students find the relationship between temperature range, annual temperature and hours of sunshine, nearness to bodies of water	Exercises 3.1-3.3	

Lesson 1

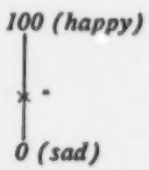
Introduction to Correlation

Objectives

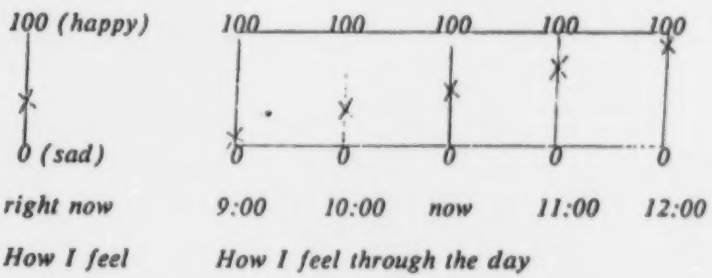
1. Understand the concept of correlation.
2. Be able to distinguish between positive correlations, negative correlations and non correlations.
3. Be able to organize and interpret correlational data.

Suggested Teaching Strategy

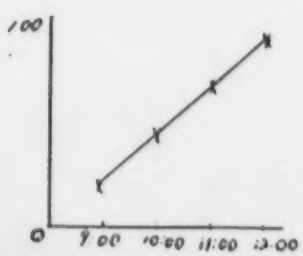
1. Provide students with motivation for learning how to solve correlational problems. For example, ask students *How do you feel right now? Rate how you feel--from 0 (sad) to 100 (happy)--on this happiness thermometer.*

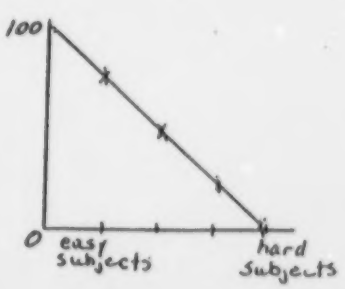


Do you feel the same all day long? Rate how you feel at 3 or 4 other times during the day, using the same scale. Put the scales together like this, so that they form a graph.



When you put several ratings together you can find patterns that might help you understand why you feel the way that you do. Look at these two examples on the board: the one on the left shows a student who feels happier the closer it is to lunch; the one on the right shows a student who feels less happy as the subjects get harder through the morning.





You can find similar patterns in many different situations, at home or in school. For example, why do you do better on some tests than others? Could your test scores be related to how hard you studied? or how much you liked the subject? or how you felt the day of the test? When you put together two things that are changing, to see if they are related, you are looking for a correlation. Here is an example

> *Mavis, a grade 7 student, met some friends on the way to school. "Why are you smoking", she said, "Don't you know it causes cancer?" Her friends started to make fun of her, telling her there was nothing to worry about, because there isn't any proof that smoking is bad for your health. But Mavis had a graph (figure 1.1) that showed there was. "Here is evidence," she said, "as the amount of tobacco consumed goes up (running her finger along the horizontal axis of the graph), the number of lung disease deaths also goes up (running her finger along the vertical axis)."*

2. Show students **how to find a correlation**, using the information in table 1.2 to find out if people who drink and drive have more accidents than nondrinkers. Write on the blackboard the three main steps in finding a correlation: make a graph; put information into the graph; read the graph.

(i) Make a graph

.draw the two axes

.give each axis a name: "Number of convicted drivers (per 100,000)" on the horizontal and "Number of Accidents (per 1,000)" on the vertical [TEACHER NOTE: It doesn't matter if this is reversed so that the number of convicted drivers goes on the vertical: the graph will show the same result; for more detail see the Introduction for the Teacher.]

.put in a scale for the horizontal axis

.the scale should begin with the highest score (St. John's with 20 convictions) and end with the lowest score (Vancouver with 130 convictions)

.divide the scale into neat units (units of 20)

.put in a scale for the vertical axis

.the scale should begin with the lowest score (St. John's with 21 accidents) and end with the highest (Vancouver with 96 accidents)

.divide the scale into neat units (units of 20)

.give the graph a title ("Drinking Drivers and Car Accidents")

(ii) Put information in the graph

.locate the first case (Fredericton) on the horizontal scale (60) and run a ruler straight up

.locate the first case (Fredericton) on the vertical scale (48) and run a ruler straight across

.place a small mark where the rulers intersect

.repeat for the rest of the cases

(iii) Read the graph

.draw a line that comes as close to each case as possible (see figure 1.2.)

.decide what kind of correlation is shown: Run your finger from left to right along the horizontal axis, *what is happening to accident rates when the number of drinking drivers goes up? [Accident rates also go up.]* Run your finger in the opposite direction along the same axis: *what happens to accident rates when drinking goes down? [Accidents also go down.]*

Tell students that this graph shows a **positive correlation.** It is called a positive correlation because the two things in the graph change in the same way; when one thing variable in the graph goes up, the other goes up; when one thing (variable) goes down, the other goes down. TEACHER NOTE: The term variable may be introduced at this point or held for a later occasion. (A variable is anything of interest that can change or take diferent values.)

3. Review the steps in making a graph, using the poster "How to Find a Correlation" containing the three main steps, with substeps for each. This poster should be prominently displayed throughout the correlational reasoning lessons.

4. Assign practice. Less able students should complete exercise 1.1 (8 cases concerning extramural sports); more able students should complete exercise 1.2 (12 cases concerning basketball). In providing feedback to students, focus attention on the three steps of the procedure: make a graph, put information in the graph; read the graph. (The correct answers are given in the exercise answers section. Included in this section is a list of the most common errors committed by students when they are making graphs.)

5. Show students an example of a **negative correlation.** Present the following situation:

> *Nancy, a grade 7 student, was telling her friends how cheap her older sister is. "Even though she has a really good job, she never has any money to loan to those in need--like me." "Come on, Nancy," said her friends, "give your sister a break. She's broke because her car insurance costs so much." "That may be true", responded Nancy, "new drivers have to pay a lot more than old drivers. It's not really fair."*

Is it fair? Show students the graph in figure 1.3. Ask students *[How is the line in this graph different from those shown before. [It is going in the opposite direction.]* Illustrate the relationship shown in the graph by selecting points on the line--the points chosen do not need to be the cases shown by the astericks). *What happens to the number of accidents when driver experience goes up from 10 years to 25 years? [the number of accidents goes down from 40 to 25] What happens when the experience of drivers goes down from 20 years to 1 year? [the number of accidents goes up from 30 to 49] The previous graphs were called positive correlations. What kind of correlation do you think this might be (a negative correlation).*

Provide table 1.3 containing information on 4 cases (pollution and lung disease). Demonstrate the procedure for finding a correlation using the steps in the poster "How to Find a Correlation": make a graph put information in the graph, read the graph. (The answer is in figure 1.4.)

6. Assign practice. Less able students should complete exercise 1.3 (8 cases concerning television and student achievement); more able students should complete exercise 1.4 (12 cases concerning student weight and flexed arm hang time). In providing feedback to students focus on the three main steps in finding a correlation.

7. Provide an example of a **non correlation.** Present the following situation

> *Some grade 7 students were doing a project on the car industry. They decided to role play: Sandra played the role of a used car salesman; Nick was the customer. Sandra's main pitch was that the 1981 "Coupe de Large" that she was trying to sell would be a safer car because it was so big. Nick thought this made a lot of sense because he figured that large cars are in fewer accidents than small cars.*

Peter, playing the role of a consumer activist, held up the information in table 1.4, claiming that it showed that Nick's idea was wrong.

Make a graph on the blackboard using the information in table 1.4 on car weight and number of accidents. (For the graph see Figure 1.5.) Have a student draw a straight line as close to the 4 cases as possible. *Does the line show a negative or a positive correlation? Is it possible to draw a different line that is just as good; (i.e that is very close to the 4 cases.)* Ask a student to draw a new line; then repeat with other students. (Examples of 9 different ways of drawing the line are given in figure 1.6.)

Point out that what is different about this graph is that no single line is any better than the rest. *In all the other examples there was one straight line that showed how the things (variables) were related. In this graph no single line will do because the things (variables) are not related: as car weight goes up, accidents may go up or down or not change; as car weight goes down, accidents may go up or down or not change. Car weight and accidents have nothing to do with one another. When two things (variables) are not related it is called a non correlation.*

8. Assign practice. Less able students should complete exercise 1.5 (8 cases concerning height and achievement); more able students should complete exercise 1.6 (12 cases concerning height and baseball batting average).

9. Review the three types of correlations. Table 1.5 provides a summary of the differences. Assign practice in distinguishing the three types. Less able students should complete exercise 1.7; more able students should complete exercise 1.8.

Evaluation

Assign Quiz #1.

FIGURE 1.1

TOBACCO CONSUMPTION AND LUNG DISEASE DEATHS

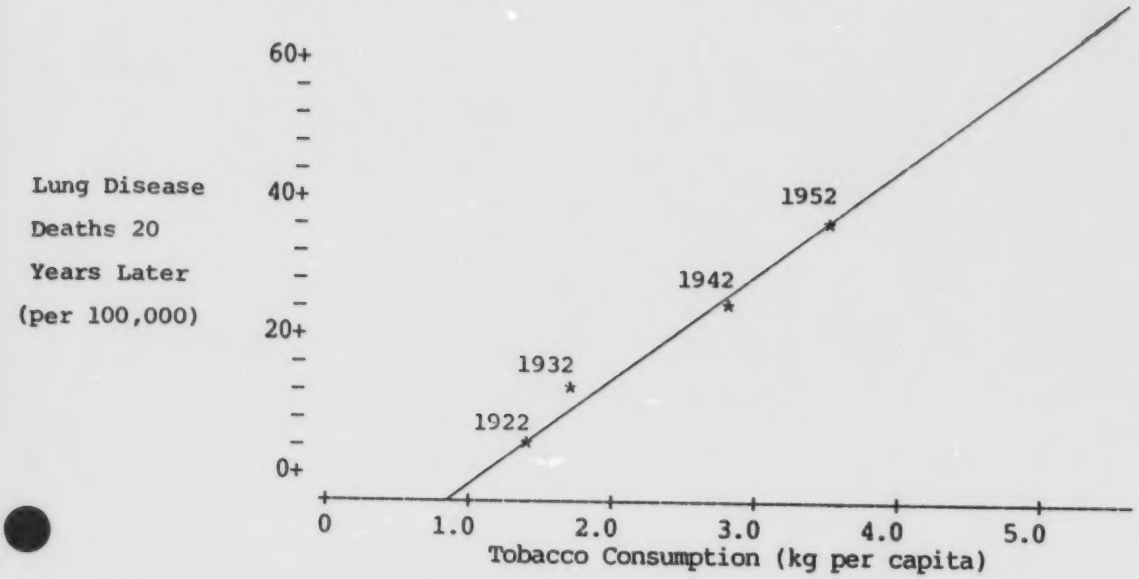


TABLE 1.2

DRINKING DRIVERS AND CAR ACCIDENTS

CITY	NUMBER OF CONVICTIONS FOR DRINKING DRIVERS PER 100,000	NUMBER OF CAR ACCIDENTS PER 100,000
Fredricton, N.B.	60	48
St. John's, Nfld.	20	21
Vancouver, B.C.	130	96
Winnipeg, Manitoba	95	73

HOW TO FIND A CORRELATION

(i) Make a graph

.draw the two axes

.give each axis a name

.put in a scale for the horizontal axis: begin with the lowest score and end with the highest

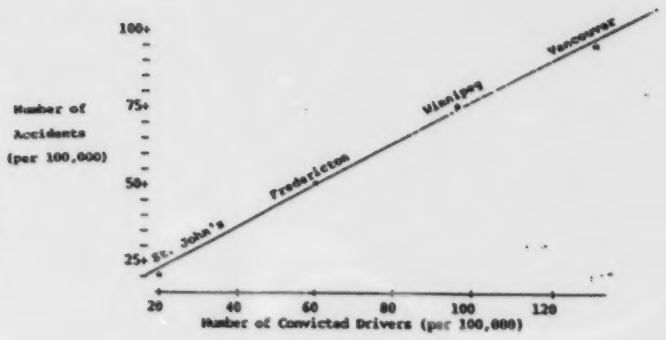
.divide the scale into units

.put in the vertical scale

.give the graph a title

FIGURE 1.2

DRINKING DRIVERS AND CAR ACCIDENTS



(ii) Put information in the graph

.locate the first case on the horizontal; run a ruler straight up

.locate the first case on the vertical; run a ruler straight across

.place a small mark where the rulers intersect

.repeat for the rest of the cases

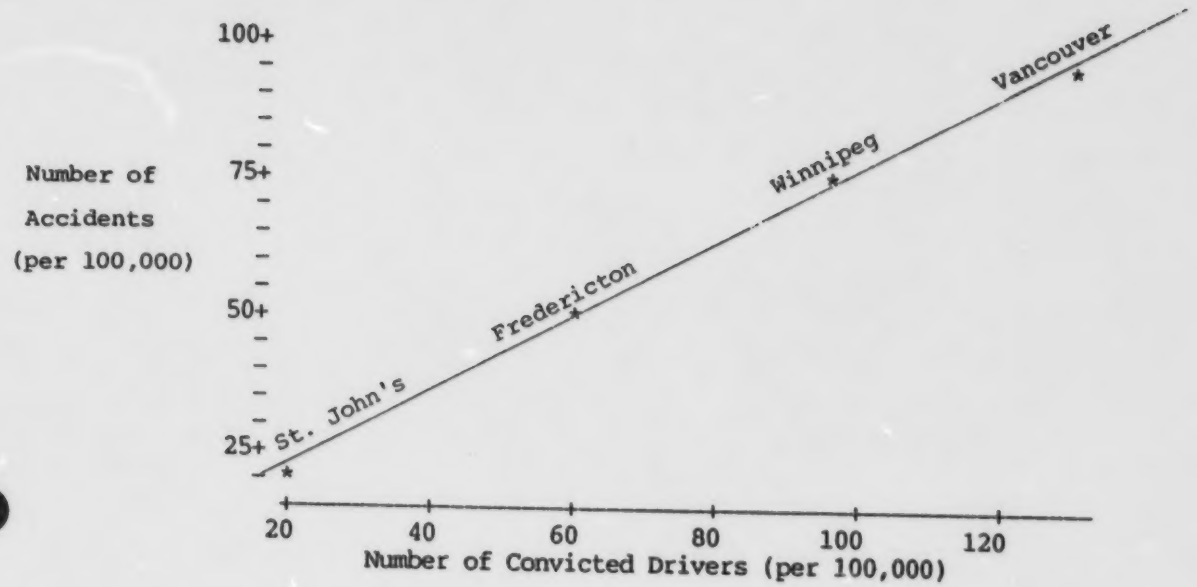
(iii) Read the graph

.draw a line that comes as close to each case as possible

.decide the kind of correlation

FIGURE 1.2

DRINKING DRIVERS AND CAR ACCIDENTS



EXERCISE 1.1

EXTRAMURAL SPORTS

Gary hasn't been doing well in school this year. He is just barely passing. "Maybe you are spending too much time in sports", says his friend Andrew.

Does the amount of time Gary spends on sports hurt his marks? The table below has information about the amount of time Gary and his friends spend in extramural sports and their marks. Use this information to find out if sports and grades are related.

Remember the 3 steps in finding a correlation:

- make a graph;
- put information in the graph;
- read the graph.

STUDENT	HOURS SPENT PER WEEK IN SPORTS	GRADES (%)
Gary	4.5	56
Bob	2.5	48
Andrew	6.5	62
Curtis	11.5	78
Stuart	10.5	75
George	12.5	85
Peter	9.0	70
David	8.0	61

EXERCISE 1.2

BASKETBALL

Michelle: "What do you mean basketball's not fair! It's my favorite sport."

Pat: "Because tall people have too much of an advantage; if you want to know which team is going to win, just get out the metre stick."

Is basketball fair? Find out if there is a relationship between the height of players and the number of points scored. Use the information in the table below.

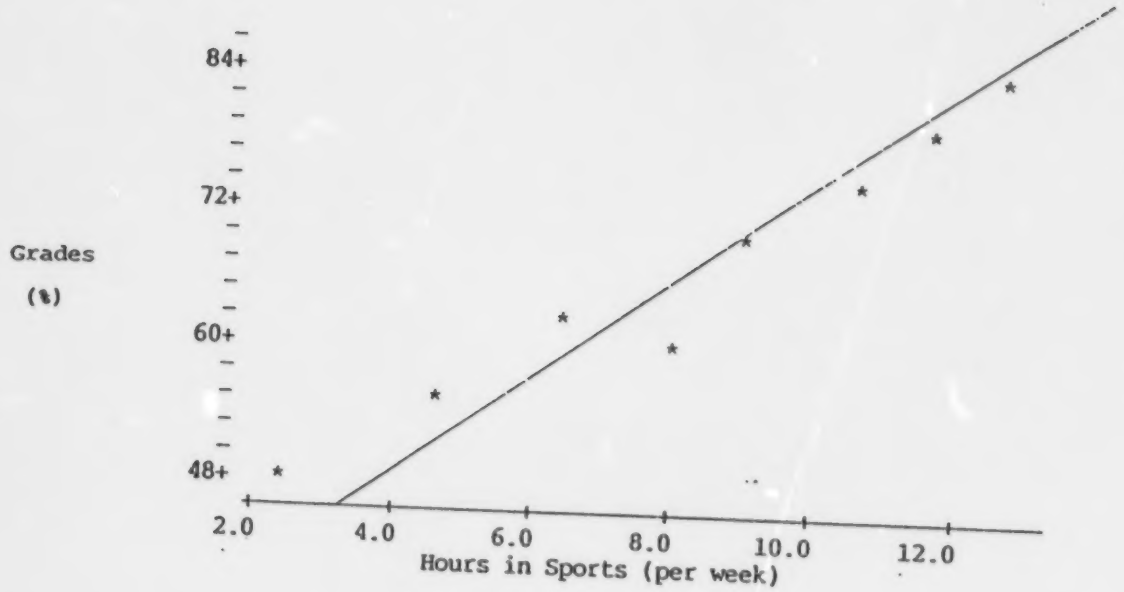
Remember the 3 steps in finding a correlation:

- make a graph;
- put information in the graph;
- read the graph.

STUDENT	HEIGHT (cm)	POINTS SCORED PER GAME
Carol	143	6
Michelle	204	38
Sarah	184	25
Tanya	154	8
Elaine	168	19
Louise	199	29
Evelyn	170	21
Tara	160	15
Anne	188	25
Pat	149	11
Nicki	194	32
Abby	175	22

ANSWER TO EXERCISE 1.1

EXTRAMURAL SPORTS AND SCHOOL ACHIEVEMENT



CORRECT ANSWER: Sports and marks are related. The graph shows a positive correlation. As the number of hours of extramural sports go up, student marks go up. Gary's poor marks are NOT the result of spending too much time in sports.

List of Common Errors Made by Students in Graphing

1. The student puts the cases on the graph in the order in which they appear in the table so that the horizontal scale reads 4.5, 2.5, 6.5, 11.5, 10.5, etc.

2. The student puts the horizontal scale in the right order (2.5, 4.5, 6.5, 8.5, 9.0, etc.) but the spacing is not right—there is the same distance between 2.5 and 4.5 as between 8.5 and 9.0.

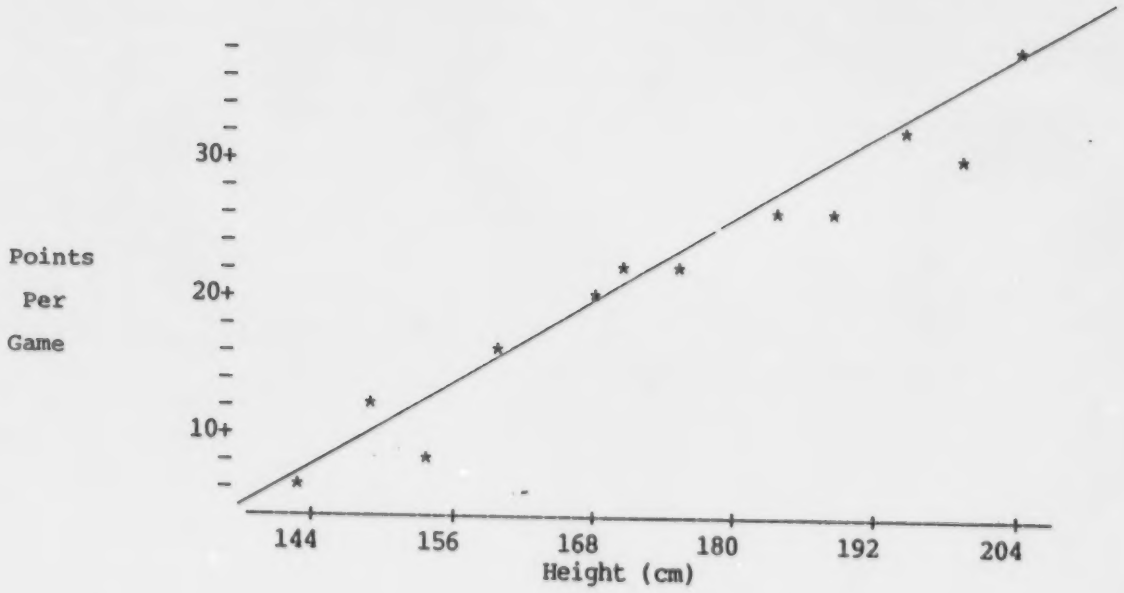
3. The horizontal axis and the vertical axis, or the graph as a whole, are not properly labelled.

4. The student connects the points in the graph using a series of lines or a curved line, rather than drawing a straight line through them.

5. The student does not extend the line beyond the cases given (which makes it harder to predict new cases from the graph).

ANSWER TO EXERCISE 1.2

STUDENT HEIGHT AND POINTS SCORED IN BASKETBALL



CORRECT ANSWER: Basketball might not be fair. The graph shows a positive correlation. As the height of players goes up, the number of points scored goes up. And look at how tall Michelle is compared to Pat.

FIGURE 1.3

DRIVER EXPERIENCE AND CAR ACCIDENTS

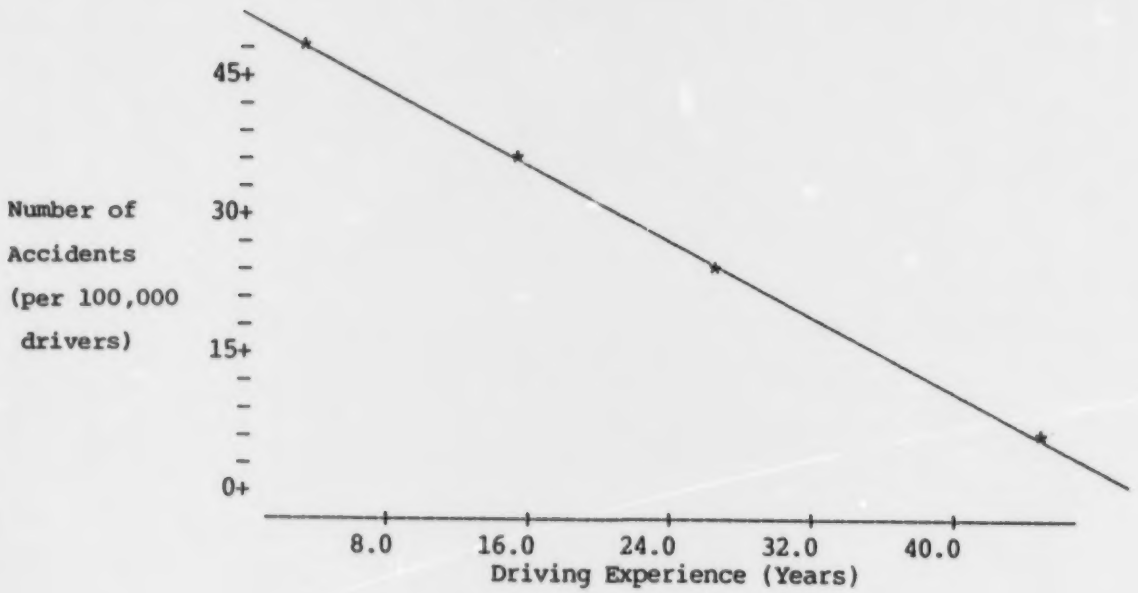


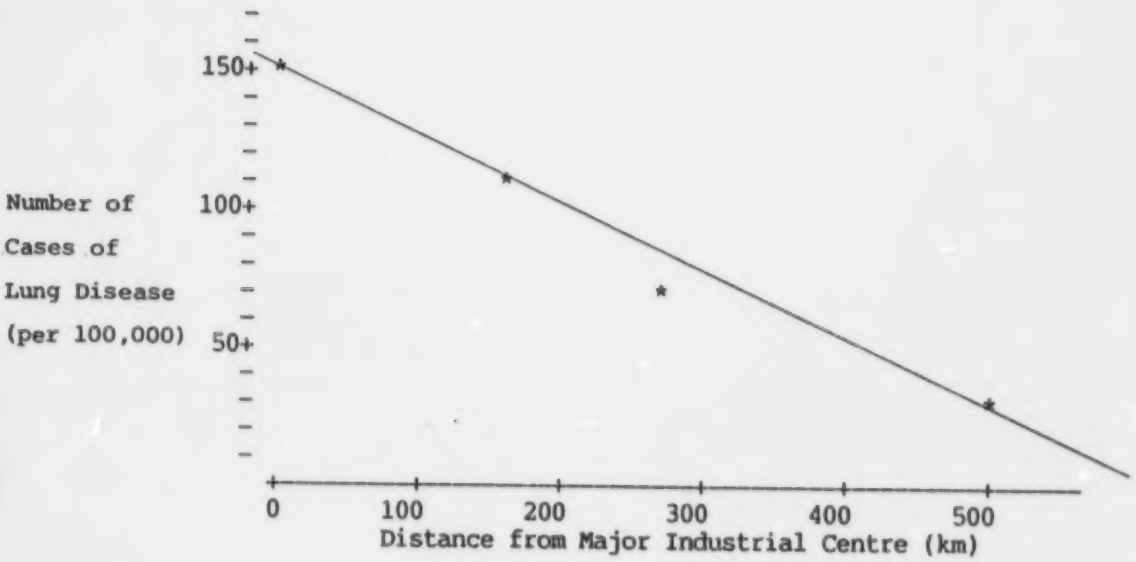
TABLE 1.3

POLLUTION AND LUNG DISEASE

CITY	DISTANCE FROM MAJOR INDUSTRIAL CENTRE (km)	NUMBER OF CASES OF LUNG DISEASE PER 100,000
Kenora, Ontario	497	27
Hamilton, Ontario	0	153
Red Deer, Alberta	273	68
Quebec City, Quebec	163	106

FIGURE 1.4

POLLUTION AND LUNG DISEASE



Exercise 1.3
Television

Cynthia: "The best way to study for a history test is in front of the tube. It relaxes you so you can really absorb that stuff about the Loyalists."

Leslie: "I can't believe I'm hearing this. The only way you're going to pass history this year is if you turn the TV off."

Who is right? Do students who watch more television get better marks? Use the information below to find out. Remember to make a graph.

STUDENT	HOURS SPENT PER WEEK WATCHING TV	GRADES (%)
Rick	31	54
Chris	20	63
Cynthia	40	42
Brian	13	75
Allan	45	36
Leslie	3	85
Doug	36	44
Marilyn	25	60

Exercise 1.4
Heavy Dudes

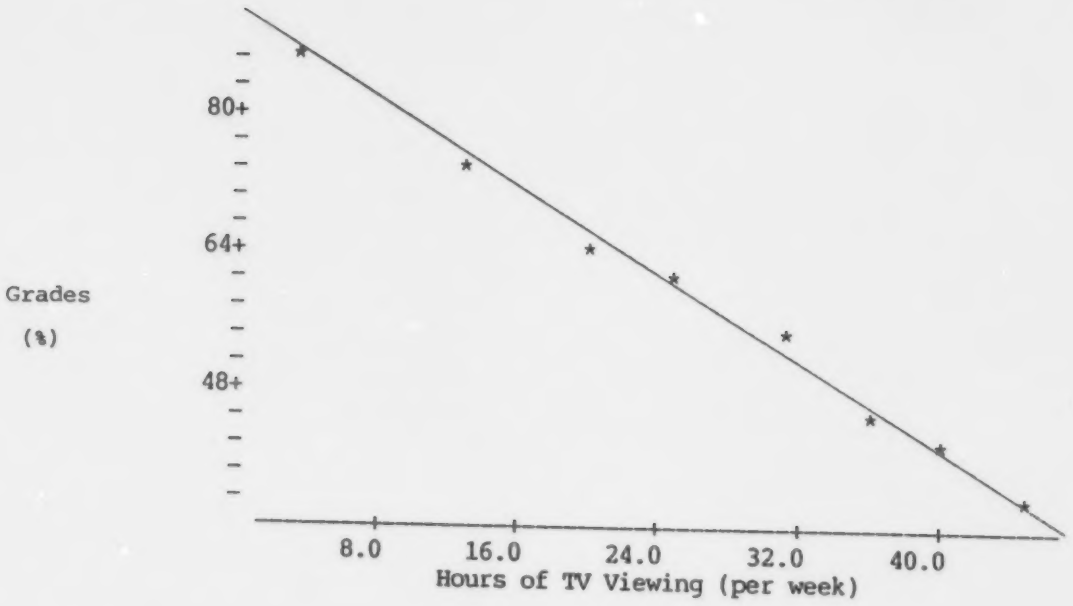
Greg and the guys were telling each other what great athletes they were. Joanne overhead the phrase "mountains of muscle" and started to laugh. "Everybody knows the best athletes are light in weight," she said. "Well I know how to prove that's not true," replied Greg, "we'll all take turns hanging by our arms from this overhead bar. If we keep careful records you will see that the heavy dudes are able to hold their chins to the bar longer."

Do the heavy dudes hang in there longer? Use the information below to find out if there is a relationship between student weight and flexed arm hang time. Remember to make a graph.

STUDENT	WEIGHT (kg)	TIME (Seconds)
Rob	60	20
Joanne	39	102
Cathy	36	119
Mark	48	61
Greg	54	37
Heather	34	126
Barb	40	96
Melanie	50	50
Janet	45	72
Ted	39	110
Jeff	43	85
Scott	57	28

ANSWER TO EXCERCISE 1.3

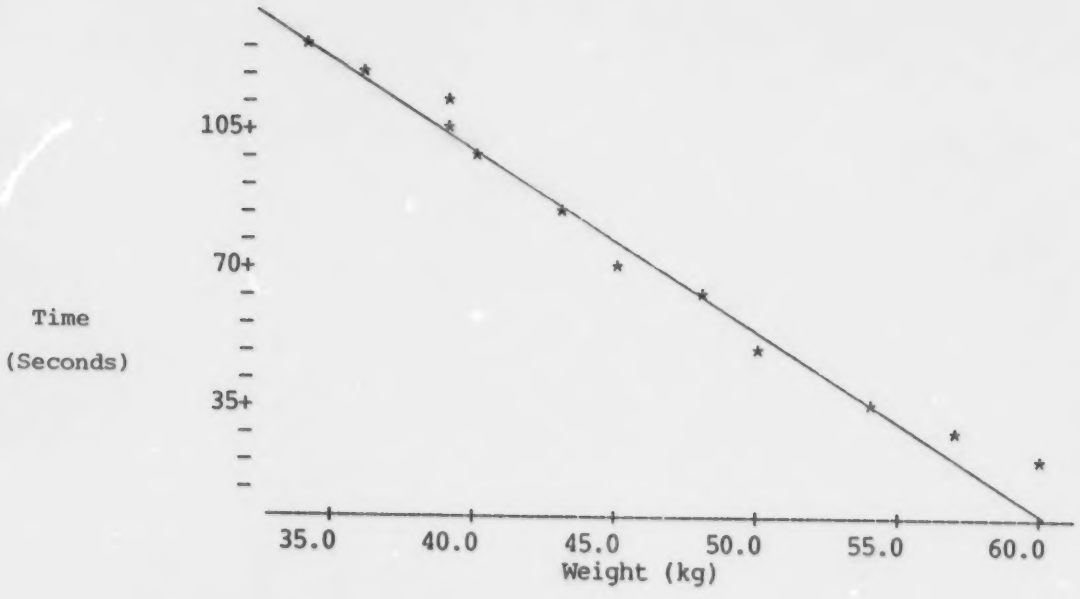
TELVISION VIEWING AND STUDENT ACHIEVEMENT



CORRECT ANSWER: Leslie is right. The graph shows a negative correlation. As the number of hours of television viewing goes up, grades go down. Cynthia should turn off the tube if she wants to pass history.

ANSWER TO EXERCISE 1.4

STUDENT WEIGHT AND FLEXED ARM HANG TIME



CORRECT ANSWER: Joanne is right. The graph shows a negative correlation. As the weight of students goes up, the flexed arm hang time goes down. The heavy dudes should be a little more humble.

TABLE 1.4

CAR WEIGHT AND CAR ACCIDENTS

CAR MANUFACTURER	AVERAGE WEIGHT OF CAR (kg)	NUMBER OF CAR ACCIDENTS PER 1,000 CARS
Suki Motors	980	10
Sklar	1410	44
Crone	960	45
Auburn	1380	8

FIGURE 1.5

CAR WEIGHT AND NUMBER OF ACCIDENTS

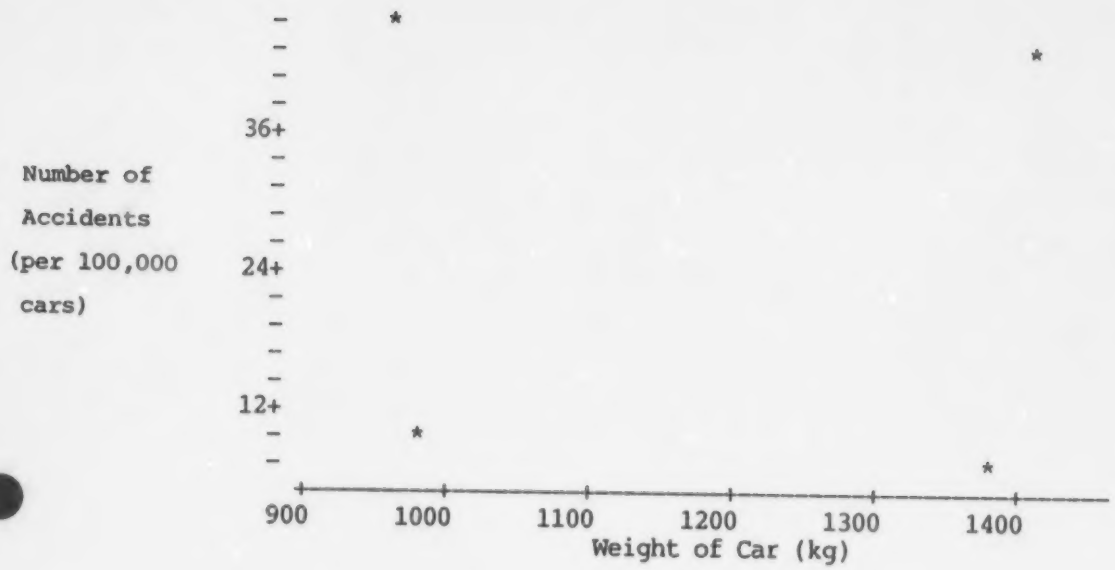
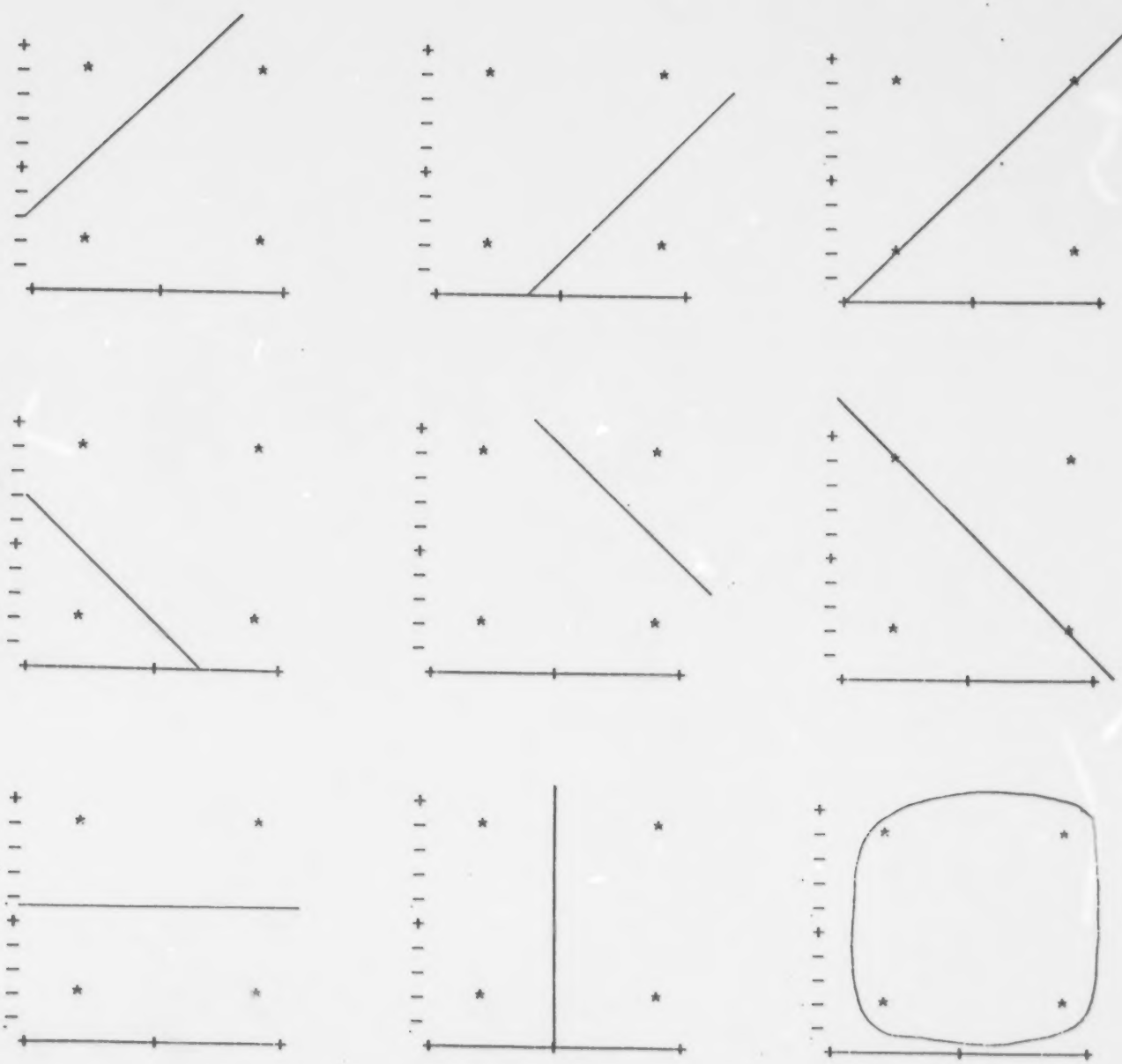


FIGURE 1.6

A NON CORRELATION: DIFFERENT WAYS OF SHOWING THE TREND



Exercise 1.5
Triumph of the Tall

"There is no justice in this world", whined Linda. "Tall people get all the breaks. They are noticed by boys more. There are more fashions for them. They get picked first for basketball. They even get better marks."

Is Linda right? Use the information in the table to find out if tall students get higher marks than short students. Remember to make a graph.

STUDENT	HEIGHT (cm)	GRADES (%)
Ashley	181	77
Karen	167	64
Emily	159	61
Elizabeth	191	69
Laura	152	75
Nancy	194	48
Linda	150	46
Sharon	181	46

EXERCISE 1.6

HEAVY HITTERS

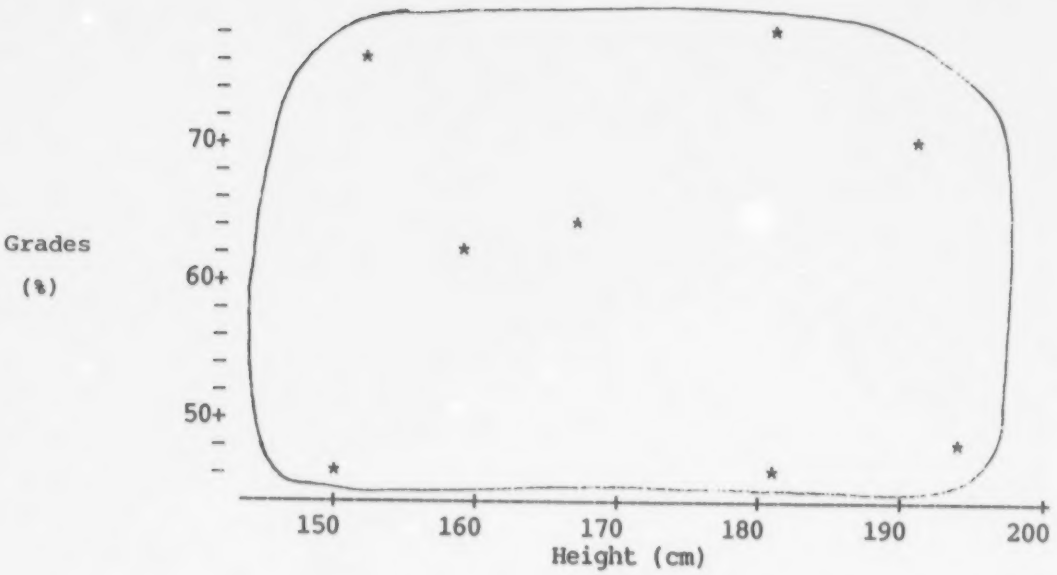
"I always look for tall, wirey guys, when I'm building a baseball team", said the old coach. "These short fellows just can't hit."

Is the old coach right? Use the information in the table to find out if tall players hit for higher averages than short players.

PLAYER	HEIGHT (cm)	BATTING AVERAGE
Dave Diamond	180	.205
Homer Run	200	.322
Peter Pitcher	153	.190
Guy Dome	170	.275
Pat Bat	170	.150
Foul Frank	200	.140
Fly Ball	183	.275
Pinch Hitter	177	.315
Mike Strike	187	.130
Baxter Catcher	150	.275
Casey Base	155	.130
Paul Ball	158	.300

ANSWER TO EXERCISE 1.5

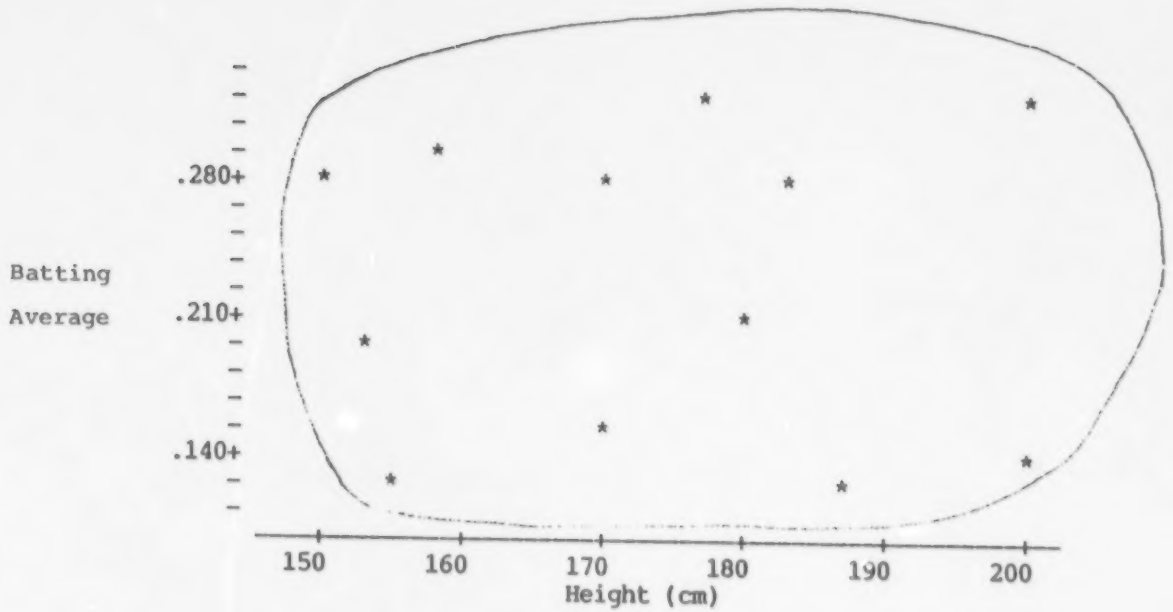
STUDENT HEIGHT AND ACHIEVEMENT



CORRECT ANSWER: Leslie is wrong. The graph shows a noncorrelation. As student height goes up, there is no consistent pattern in the marks received.

ANSWER TO EXERCISE 1.6

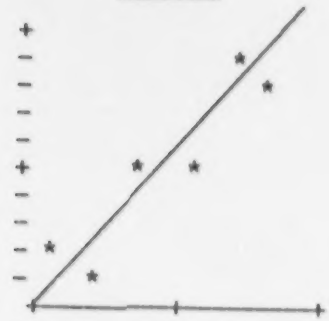
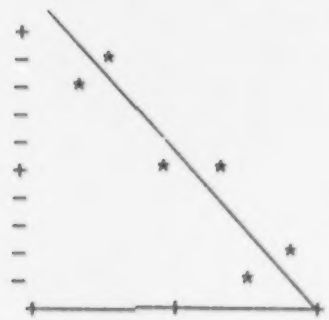
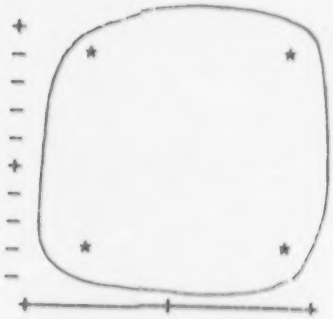
HEIGHT AND BASEBALL BATTING AVERAGE



CORRECT ANSWER: The old coach is wrong. The graph shows a noncorrelation. As student height goes up, there is no consistent pattern in batting averages. Maybe the old coach was thinking about the number of home runs hit by tall and short players?

TABLE 1.5

TYPES OF CORRELATIONS

Type	Example	Definition
Positive Correlation		as one thing changes, the other changes in the same way
Negative Correlation		as one thing changes, the other changes in the opposite way
Non Correlation		as one thing changes, there is no pattern in the other factor

EXERCISE 1.7
WHAT KIND OF CORRELATION IS THIS?

There are 2 graphs on this page and 2 more on the next.

For each graph:

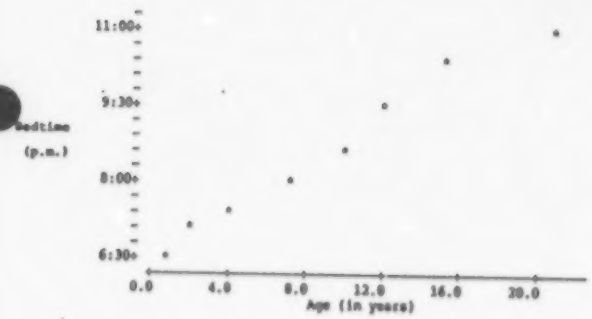
a) draw a line or circle on the graph showing the correlation;

b) state what kind of correlation it is;

c) state what will happen to the vertical thing when the horizontal thing goes up.

EXERCISE 1.7A

AGE OF CHILD AND BEDTIME



b) _____

c) _____

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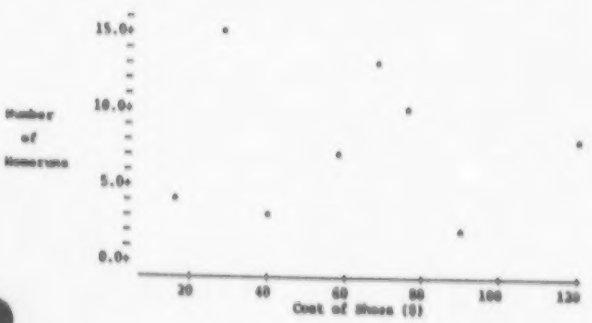
EXERCISE 1.7 B

NUMBER OF HOMERUNS AND COST OF RUNNING SHOES



b) _____

c) _____

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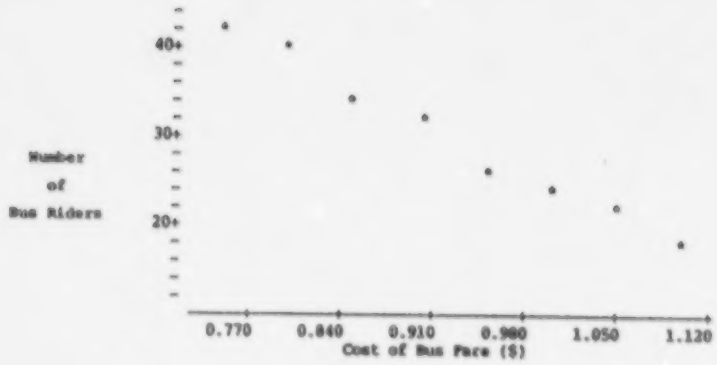
_____

EXERCISE 1.7 C

NUMBER OF BUS RIDERS AND FARE



b) _____

c) _____

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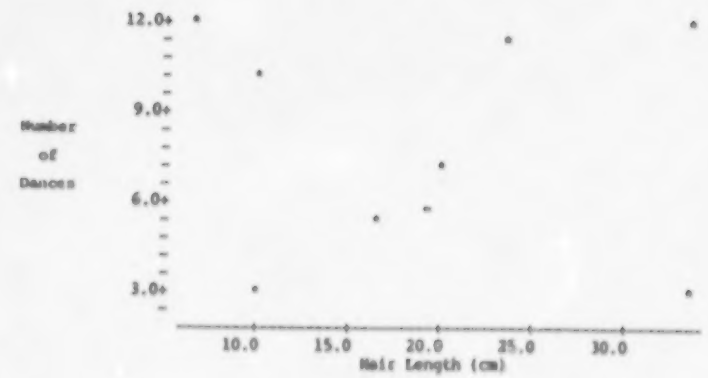
EXERCISE 1.7 D

NUMBER OF DANCES AND LENGTH OF HAIR



b) _____

c) _____

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_____

ANSWER TO EXERCISE 1.7

Bedtime: There should be a straight line running from bottom left to upper right. This is a positive correlation. When the age of the child goes up, bedtime is later.

Homeruns & Cost of Running Shoes: There should be a circle around the cases. This is a noncorrelation. When the cost of the running shoes goes up, there is no consistent pattern in the number of home runs.

Bus Riders & Bus Fare: There should be a straight line running from top left to bottom right. This is a negative correlation. When the bus fare goes up, the number of riders goes down.

Dances & Length of Hair: There should be a circle around the cases. This is a noncorrelation. When the length of hair goes up, there is no consistent pattern in the number of dances.

EXERCISE 1.8

WHAT KIND OF CORRELATION IS THIS?

There are 2 graphs on this page and 2 more on the next about factors affecting rainfall.

For each graph:

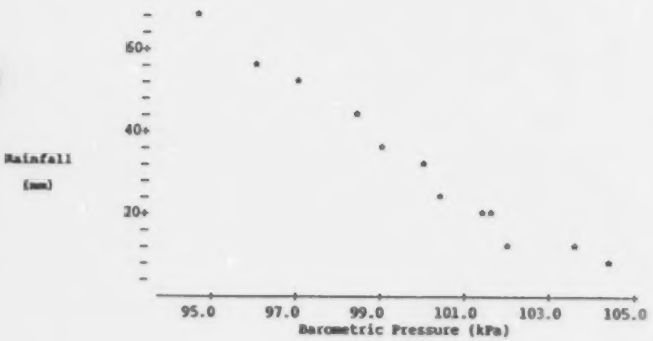
a) draw a line or circle on the graph showing the correlation;

b) state what kind of correlation it is;

c) state what will happen to the vertical thing when the horizontal thing goes up.

EXERCISE 1.8 A

BAROMETRIC PRESSURE AND RAINFALL



b) _____

c) _____

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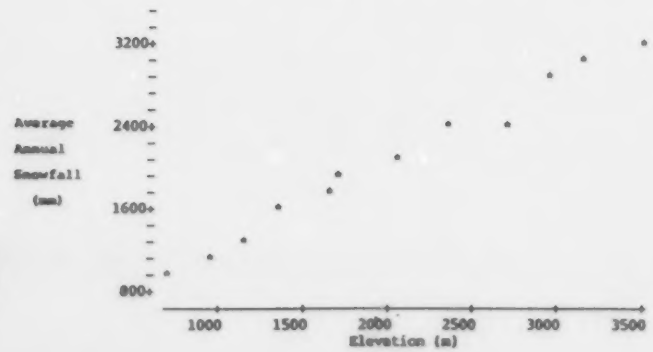
EXERCISE 1.8 B

ELEVATION AND SNOWFALL IN ALBERTA



b) _____

c) _____

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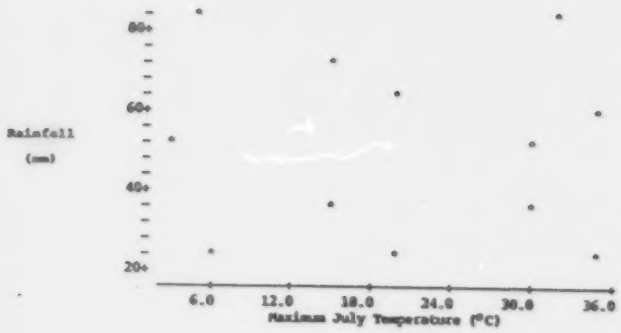
EXERCISE 1.8 c

TEMPERATURE AND RAINFALL



b) _____

c) _____

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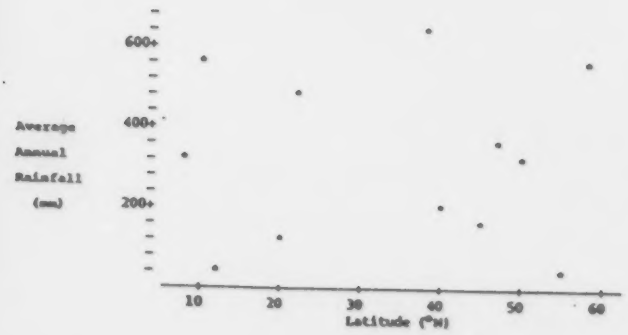
EXERCISE 1.8 d

LATITUDE AND RAINFALL



b) _____

c) _____

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_____

_____

ANSWER TO EXERCISE 1.8

Barometer: There should be a straight line running from top left to bottom right. This is a negative correlation. When the barometer goes up, rainfall goes down.

Elevation: There should be a straight line running from bottom left to upper right. This is a positive correlation. When the elevation in Alberta goes up, the annual snowfall goes up.

Temperature: There should be a circle around the cases. This is a noncorrelation. When temperature goes up, there is no consistent pattern in rainfall.

Latitude: There should be a circle around the cases. This is a noncorrelation. When Latitude goes up, there is no consistent pattern in rainfall.

QUIZ 1

CASTING A LIGHT ON CRIME OR CATCHING CRIMINALS?

The Mayberry City Council had a problem: crime in mall parking lots. Alderman Jones said, "We need more patrols. Let's hire an extra police officer. Crime will go down when the criminals know they are more likely to be caught." But Alderman Walton had a different idea. "Let's install more lights in the malls. Crime will go down when the criminals know they can be seen."

a) Who was right? Use the information in the table to find out if the mall lighting and crime are related.

b) What kind of correlation is this?

c) What will happen to the number of crimes, if the number of lights goes up?

CRIME IN MAYBERRY MALL PARKING LOTS

MALL	NUMBER OF CRIMES/YEAR	NUMBER OF LIGHTS
Westwind Place	19	120
Fairmount Shopping Centre	40	40
Lakeside Centre	2	200
Ridgeview Plaza	12	145
Town Square	26	100
Bayview Mall	48	20
Auburn Lanes	5	180
Pinecrest Mall	32	65

MARKING QUIZ 1

Make a Graph - 10 marks

.names each axis "number of crimes" and "number of lights"	2 marks
.puts in horizontal scale from lowest score (1 mark) to highest score (1 mark) in neat units (1 mark)	3 marks
.puts in vertical scale	3 marks
.labels graph "Crime & lighting in Mayberry"	2 marks

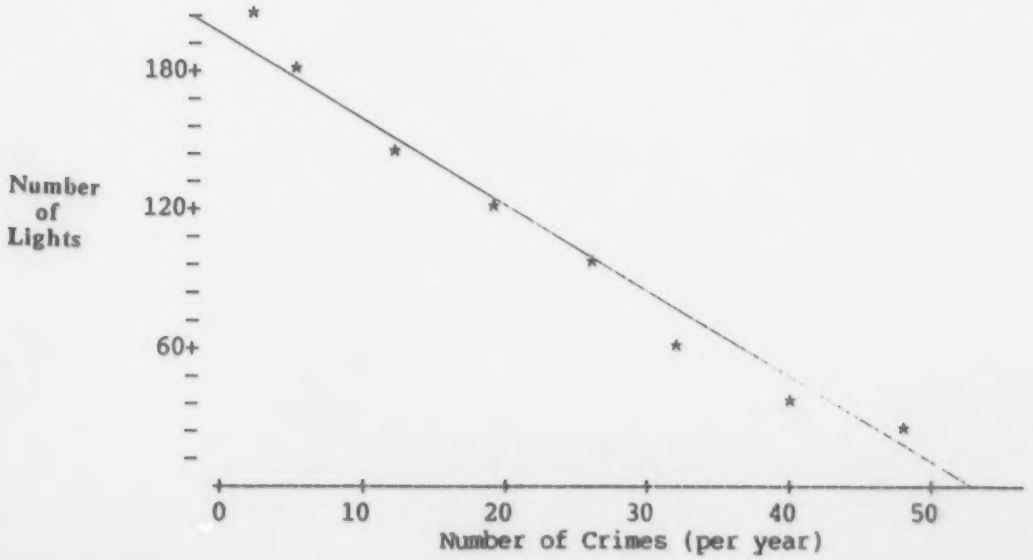
Put Information in the Graph - 5 marks

.puts all data in graph correctly (3 marks if one error 1 mark if two errors)	5 marks

Read the Graph - 5 marks

.draws a line through the cases	2 marks
.states it is a negative correlation	1 mark
.concludes "when lighting goes up, crime goes down"	2 marks

CRIME IN MAYBERRY MALL PARKING LOTS



LESSON 2
GEOGRAPHIC CORRELATION

Objectives

1. To be able to organize and interpret correlational data in geographic problems.

2. To understand the relationship between latitude and temperature.

Suggested Teaching Strategy

1. Provide students with information on latitude, longitude and temperature. Have them find out which affects temperature: latitude or longitude. Three versions of the problem are provided; these versions increase in difficulty as described below. Students may work from the tables or from the graphs, depending upon the choice of the teacher, or they might be asked to work from one of the tables (e.g. longitude and temperature) and one of the figures (e.g. latitude and temperature).

- Tables/figures 2.1 and 2.2 contain data on North America; these data confirm student expectations that it gets warmer the farther south you go.

- Tables/figures 2.3 and 2.4 contain data on South America; these data contradict student expectations that it gets warmer the farther south you go.

- Tables/figures 2.5 and 2.6 contain data on Africa; students must plot the cases using distance from the equator without regard to whether they are north or south of it.

2. Provide individual assistance as students work through the task. If students encounter difficulty, refer them to the poster "How to Find a Correlation". Take up the results: the correct answers are in figures 2.7 - 2.9. Students should recognize that

- the latitude - temperature data produce a negative correlation: as distance from the equator goes up, temperature goes down;

- the longitude - temperature data produce a non correlation: there is no pattern between the changes in longitude and the changes in temperature

Evaluation

Feedback should focus on the skill goals, (the steps involved in finding a correlation), as well as the knowledge goals.

Exercise 2.1

A Christmas Vacation

"Am I ever glad we are going away this Christmas!" said Joanne.
"I'm tired of being cold all the time; I hope we go a long way south."
"You are in for a surprise," argued Teri, "just because it is south of here doesn't mean it's any warmer. If you want to be warm you should go west."

Who is right - Joanne or Teri? Use the information in the tables to find out if a) latitude and temperature are related. Then find out if b) longitude and temperature are related. Remember to make one graph for EACH correlation.

TABLE 2.1

LATITUDE AND TEMPERATURE FOR NORTH AMERICA

PLACE NAME	LATITUDE (°N)	AVERAGE TEMPERATURE (°C)
Prince George, B.C.	54	4
Mazatlan, Mexico	23	24
Boston, Mass.	42	11
Halifax, N.S.	45	7
Grand Junction, Colorado	39	11
Huston, Texas	30	21
Miami, Florida	26	24
Acapulco, Mexico	17	28
Regina, Sask.	50	2
San Francisco, Ca.	38	14
Toronto, Ontario	44	8
Winnipeg, Manitoba	50	2

TABLE 2.2

LONGITUDE AND TEMPERATURE FOR NORTH AMERICA

PLACE NAME	LONGITUDE (°W)	AVERAGE TEMPERATURE (°C)
Prince George, B.C.	123	4
Mazatlan, Mexico	106	24
Boston, Mass.	71	11
Halifax, N.S.	64	7
Grand Junction, Colorado	109	11
Huston, Texas	95	21
Miami, Florida	80	24
Acapulco, Mexico	100	28
Regina, Sask.	105	2
San Francisco, Ca.	122	14
Toronto, Ontario	80	8
Winnipeg, Manitoba	97	2

FIGURE 2.1

LATITUDE AND TEMPERATURE FOR NORTH AMERICA

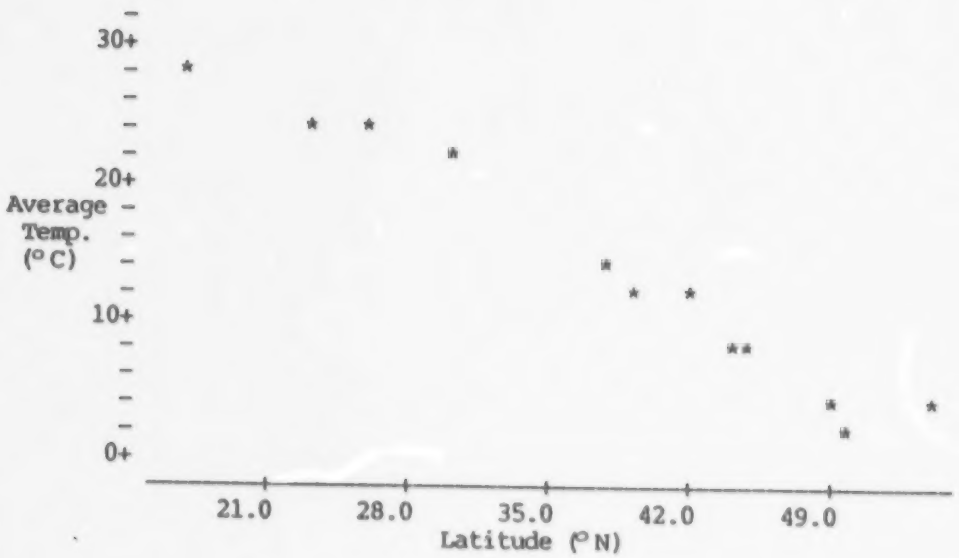
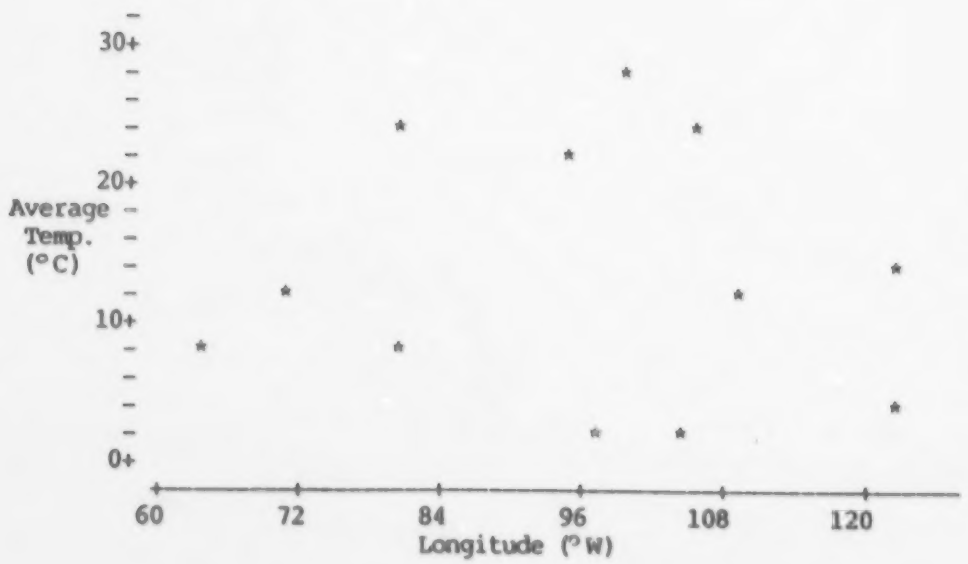


FIGURE 2.2

LONGITUDE AND TEMPERATURE FOR NORTH AMERICA



Exercise 2.1

A South American Tour

Kelly had some news: "Our principal, Ms Strict, is going on a tour of South America. She is going to sail around the southern tip of the continent in July. Can you imagine how hot it must be that far south? She had better take lots of shorts and sandals." "I'll bet you are right about that", said Mallory, "mind you, it would be even hotter if she was going west."

Who is right - Kelly or Mallory? Use the information in the tables to find out if a) latitude and temperature are related. Then find out if b) longitude and temperature are related. Remember to make one graph for EACH correlation.

TABLE 2.3

LATITUDE AND TEMPERATURE FOR SOUTH AMERICA

PLACE NAME	LATITUDE (°S)	AVERAGE TEMPERATURE (°C)
Conceicao de Araguaia, Brazil	8	25
Concepcion, Bolivia	16	24
Manus, Brazil	3	27
Sao Paulo, Brazil	24	19
Montevideo, Uruguay	35	16
Turiacu, Brazil	2	27
Santa Cruz, Bolivia	18	23
Teresina, Brazil	5	27
Buenos Aries, Argentina	35	17
Iquitos, Peru	4	26
Porto Alegre, Brazil	30	20
Yacuiba, Bolivia	22	22

TABLE 2.4

LONGITUDE AND TEMPERATURE FOR SOUTH AMERICA

PLACE NAME	LONGITUDE (°W)	AVERAGE TEMPERATURE (°C)
Conceicao de Araguaia, Brazil	49	25
Concepcion, Bolivia	62	24
Manus, Brazil	60	27
Sao Paulo, Brazil	46	19
Montevideo, Uruguay	56	16
Turiacu, Brazil	45	27
Santa Cruz, Bolivia	63	23
Teresina, Brazil	43	27
Buenos Aries, Argentina	58	17
Iquitos, Peru	73	26
Porto Alegre, Brazil	51	20
Yacuiba, Bolivia	64	22

FIGURE 2.3

LATITUDE AND TEMPERATURE FOR SOUTH AMERICA

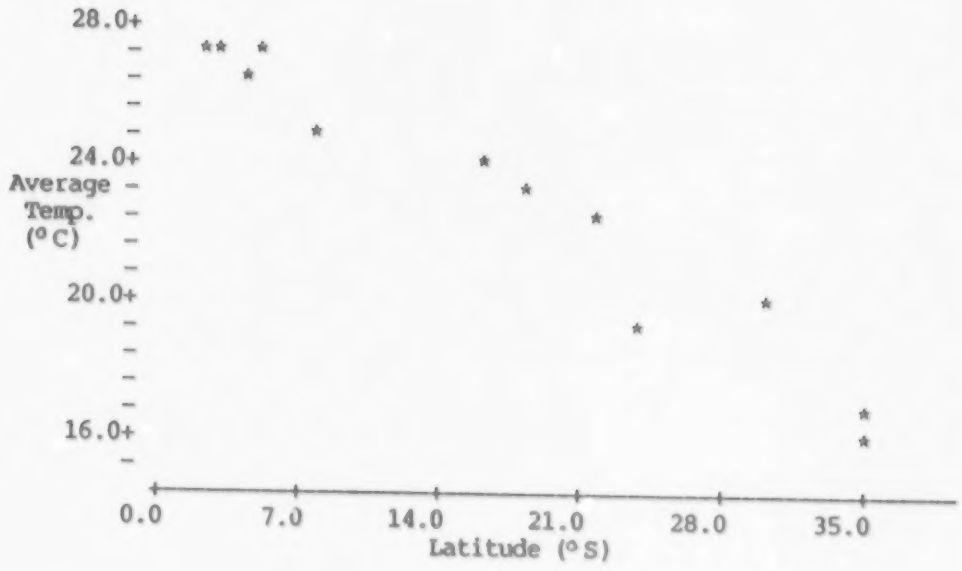
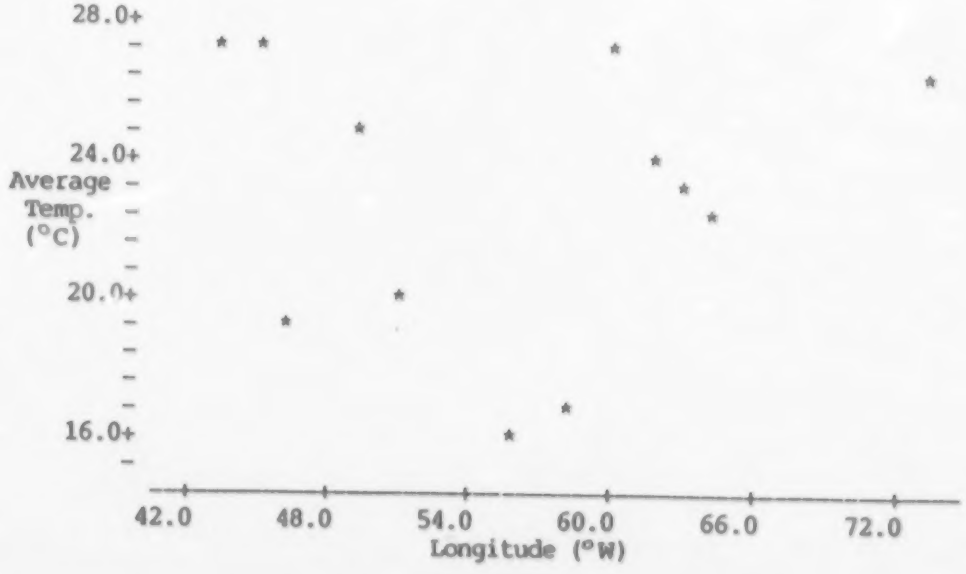


FIGURE 2.4

LONGITUDE AND TEMPERATURE FOR SOUTH AMERICA



Exercise 2.1

African Safari

"Look at this, I'm already a winner!" said John as he ripped open the envelope from Sleazy Promotions Limited. "All I have to do is subscribe to six magazines and I'll win an African safari. It goes right across the continent so I'll need heavy clothing at the beginning and lighter clothing the farther west we go." "I don't think you have to worry about it", laughed Steve. "Sleazy Publications is not the most reputable of firms. Besides everybody knows that if you want to get warm you go south, not west."

Who is right - John or Steve? Use the information in the tables to find out if a) latitude and temperature are related. Then find out if b) longitude and temperature are related. Remember to make one graph for EACH correlation.

TABLE 2.5

LATITUDE AND TEMPERATURE FOR AFRICA

PLACE NAME	LATITUDE (DISTANCE FROM EQUATOR)	AVERAGE TEMPERATURE (°C)
Cape Town, South Africa	34	17
Mahalapye, Botswana	23	21
Beit Bridge, Zimbabwe	22	22
Kimberley, South Africa	29	18
Tunis, Tunisia	36	18
Nouakchott, Mauritania	18	25
Malakal, Sudan	9	27
St. Louis, Senegal	16	25
Conakry, Guinea	10	26
Lobito, Angola	12	24
Mandera, Kenya	3	29
Bamako, Mali	13	26

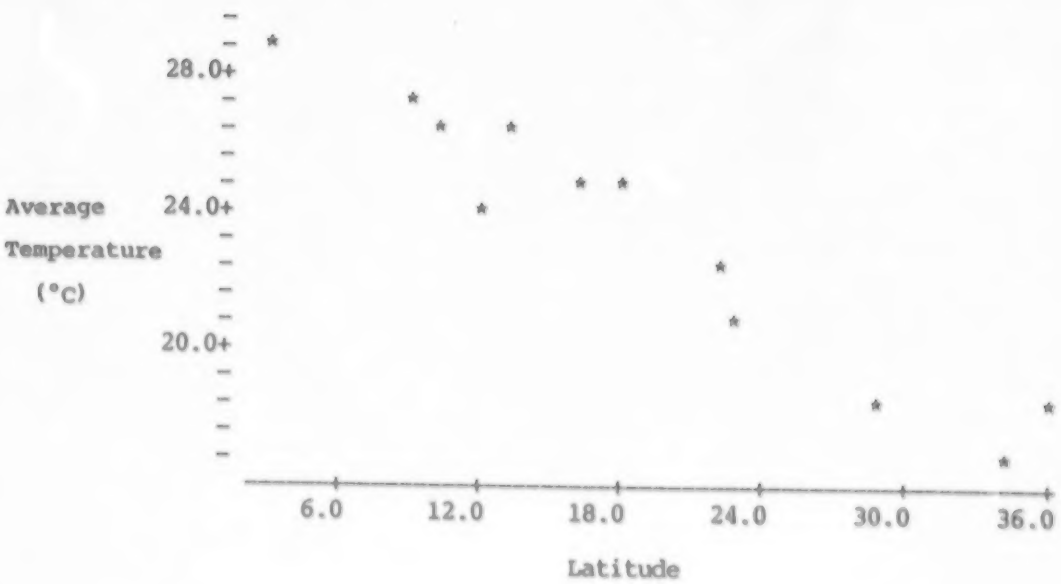
TABLE 2.6

LONGITUDE AND TEMPERATURE FOR AFRICA

PLACE NAME	LONGITUDE	AVERAGE TEMPERATURE (°C)
Cape Town, South Africa	18°E	17
Mahalapye, Botswana	26°E	21
Beit Bridge, Zimbabwe	30°E	22
Kimberley, South Africa	25°E	18
Tunis, Tunisia	10°W	18
Nouakchott, Mauritania	16°W	25
Malakal, Sudan	32°E	27
St. Louis, Senegal	16°W	25
Conakry, Guinea	14°W	26
Lobito, Angola	14°E	24
Mandera, Kenya	42°E	29
Bamako, Mali	8°W	26

FIGURE 2.5

LATITUDE AND TEMPERATURE FOR AFRICA



NOTE: Latitude is given in terms of distance from the equator, both °N and °S.

FIGURE 2.6

LONGITUDE AND TEMPERATURE FOR AFRICA

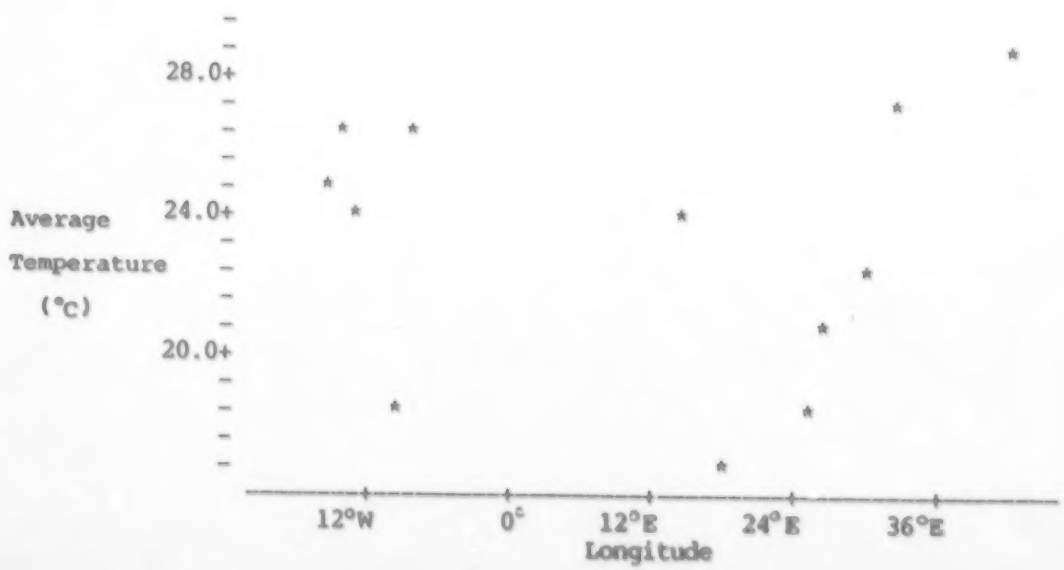


FIGURE 2.7

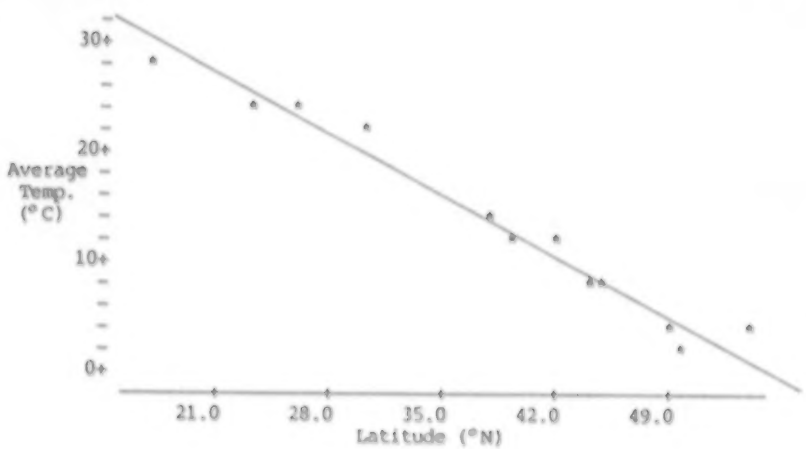
ANSWERS TO A CHRISTMAS VACATION

Joanne is right.

a) The graph for latitude and temperature shows a negative correlation: as distance from the equator goes up, temperature goes down;

b) The graph for longitude and temperature shows a non correlation: as longitude goes up, there is no consistent pattern in the temperature.

LATITUDE AND TEMPERATURE FOR NORTH AMERICA



LONGITUDE AND TEMPERATURE FOR NORTH AMERICA

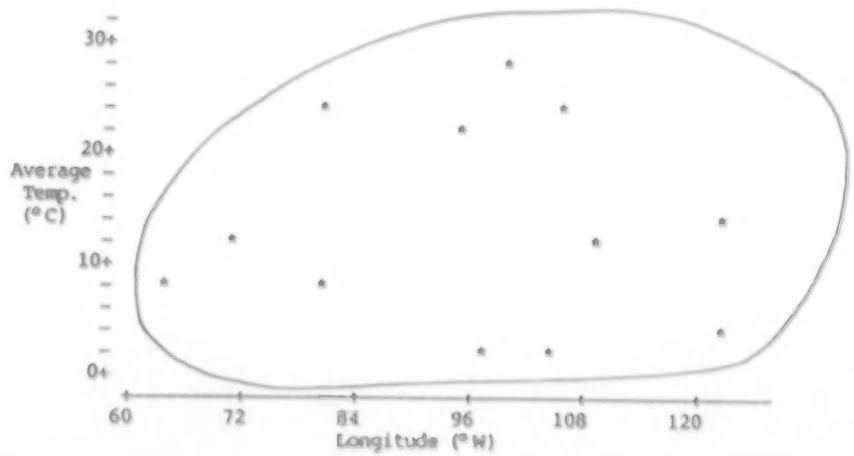


FIGURE 2.8

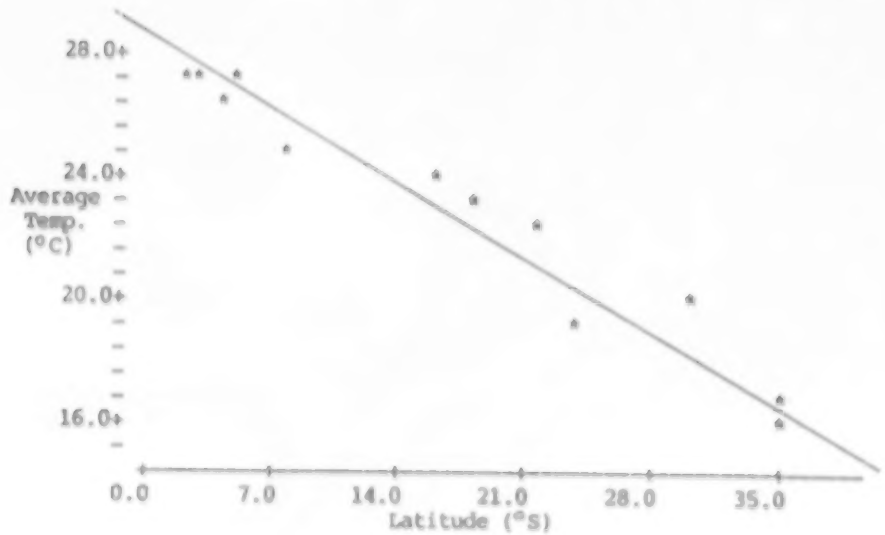
ANSWERS TO A SOUTH AMERICAN TOUR

Neither Kelly nor Mallory is right.

a) The graph for latitude and temperature shows a negative correlation: as distance from the equator goes up, temperature goes down. In South America it gets colder as you go south.

b) The graph for longitude and temperature shows a non correlation: as longitude goes up, there is no consistent pattern in the temperature.

LATITUDE AND TEMPERATURE FOR SOUTH AMERICA



LONGITUDE AND TEMPERATURE FOR SOUTH AMERICA

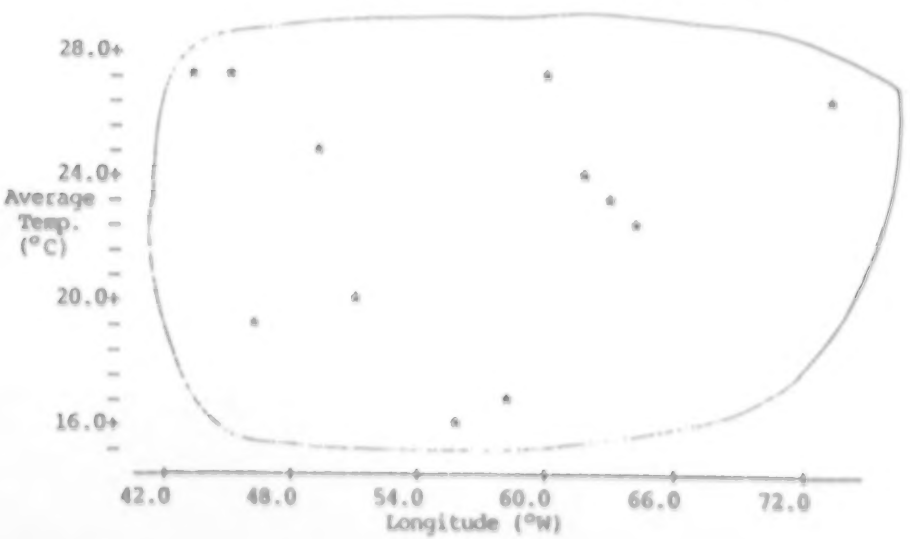


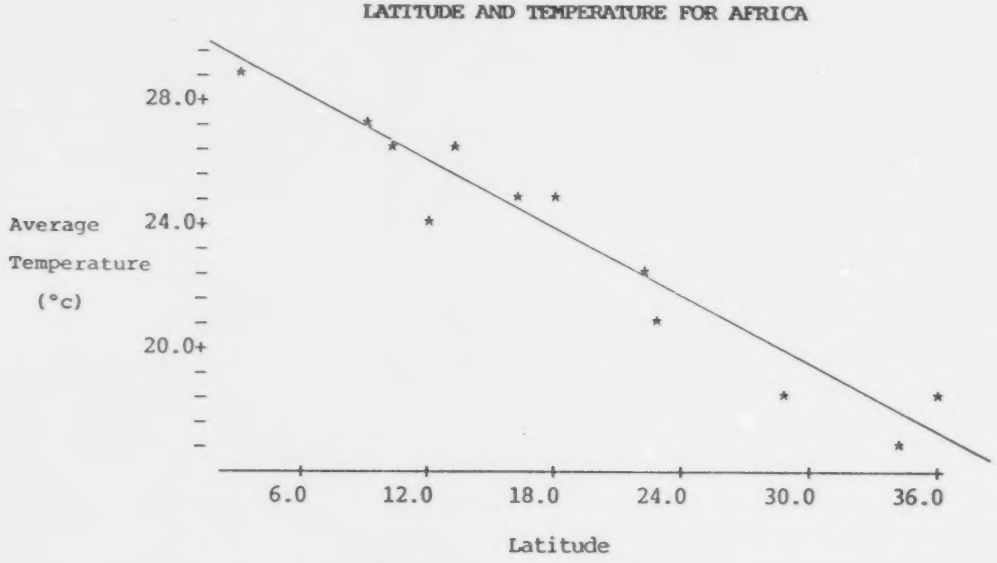
FIGURE 2.9

ANSWERS TO AN AFRICAN SAFARI

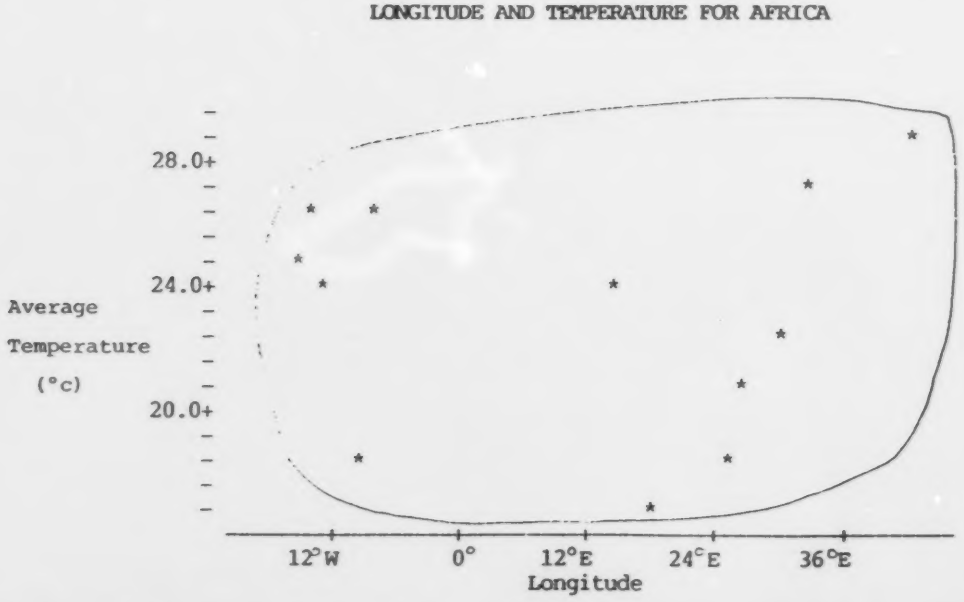
Neither John nor Steve is right.

a) The graph for latitude and temperature shows a negative correlation: as distance from the equator goes up, temperature goes down. In Africa it gets warmer as you go south until you get to the equator. Once you pass the equator, it gets colder as you go south.

b) The graph for longitude and temperature shows a non correlation: as longitude goes up, there is no consistent pattern in the temperature.



NOTE: Latitude is given in terms of distance from the equator, both °N and °S.



Lesson 3
Controlling Variables in a Correlational Problem

Objectives

1. To be able to control variables when organizing and interpreting correlational data.

2. To understand the variables that affect temperature, including elevation and nearness to large bodies of water.

Suggested Teaching Strategy

1. Most grade 7 students know that it gets colder as elevation increases. Tables 3.1 - 3.3 contain data on temperature, latitude and elevation in three continents. Have students find the relationship between elevation and temperature for each set of data. [Teachers may wish to have each student do all three sets or divide up the task so each student does only one.]

2. Display the results. Figure 3.1 shows that there is a negative correlation between elevation and temperature (the higher you get, the colder it is); figure 3.2 shows there is a non correlation (height has nothing to with temperature); figure 3.3 shows there is a positive correlation (the higher you get, the warmer it is);

Invite students to explain why such different results were found. Direct students' attention to the latitude information; remind them that they have just found that latitude makes a difference to temperature.

.In table 3.1 all the places are within the same band of latitude. The comparison of different elevations is a fair one because latitude is kept more or less the same for all the places.

.In table 3.2 latitude is not kept the same; some of the high elevation places are near the equator and some of the low elevation places are distant from the equator. This distorts the results. There is a relationship between elevation and temperature but we can't see it because the relationship between latitude and temperature is in the way. Table 3.2a and figure 3.2a show what happens when places are selected within the same band of latitude: the correct negative correlation between elevation and temperature is visible.

.In table 3.3 the effect of latitude is even more extreme. All the high elevation places happen to be near the equator and all of the low elevation places happen to be distant from the equator. The relationship between latitude and temperature is so strong that it completely overturns the relationship between elevation and temperature. Table 3.3a and figure 3.3a show what happens when places are selected within the same band of latitude: the correct negative correlation between elevation and temperature is visible.

Provide students with a few real life examples in which it is necessary to control for some other variable; [see table 3.4 for examples]; ask students to think of additional examples.

> **TEACHER NOTE: Many students think that you can make statistics say whatever you want. It is important for them to realize that this is not the case if you control for variables that might distort the results.**

3. In previous exercises information on temperature was limited to the average temperature for each location. Ask students to identify other kinds of temperature information. List on the

board. Ask students to think of climate variables that might explain why it is colder in some places than in others. List on the board.

Tell students that they will be given two kinds of information about temperature (range and annual temperature) along with data on nearness to bodies of water and hours of sunshine. Each set of cases will be taken from the same range of latitude. List on the board the 4 possible relationships between temperature and other climate variables that could be investigated with these data.

- average annual temperature and nearness to bodies of water
- average annual temperature and hours of sunshine
- temperature range and nearness to bodies of water
- temperature range and hours of sunshine

Have students predict the relationships which are most and least likely to be true. Emphasize that in these investigations, unlike the previous ones, the effect of latitude is controlled by using places from within the same band of latitude.

Have students investigate two relationships of interest: two variables that the student thinks are not related and two variables that probably are. The information is contained in table 3.5. OR Have students investigate all the relationships using figures 3.5 - 3.9. Students should notice that all the places in the table are within the **same** band of latitude.

4. Provide remedial assistance as students work through the problem by drawing their attention to the poster "How to Find a Correlation". Emphasize that in these investigations the effect of latitude is controlled.

Evaluation

1. Provide students with feedback on the skill goals (the steps in the poster "How to Find a Correlation".

2. Students should conclude the following

Figure 3.5 - there is a positive correlation between temperature range and distance to large bodies of water; the closer you get to the ocean, the lower the temperature range;

Figure 3.6 - there is a negative correlation between annual temperature and nearness to large bodies of water; the farther you are from the ocean, the lower the annual temperature; **Teacher Note**: This relationship applies only in the band of latitude given in the title of the figure;

Figure 3.7 - there is no correlation between temperature range and hours of sunshine; when the number of hours of sunshine increases there is no consistent pattern in the temperature range;

Figure 3.8 - there is no correlation between average annual temperature and hours of sunshine; when the number of hours of sunshine increases there is no consistent pattern in the average annual temperature;

TABLE 3.1

LATITUDE, ELEVATION AND TEMPERATURE

IN EURASIA

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (°N)
Bordeaux, France	20	12	44
Lyon, France	21	11	45
Friedrichshafen, Germany	407	9	47
Urumchi, China	913	5	43

TABLE 3.2

LATITUDE, ELEVATION AND TEMPERATURE

IN NORTH AMERICA

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (°N)
Ely, Nevada	1909	7	39
San Diego, Ca.	0009	17	33
Morelia, Mexico	1923	18	20
Yakutat, Alaska	0009	4	60

TABLE 3.3

LATITUDE, ELEVATION AND TEMPERATURE

IN SOUTH AMERICA

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (° S)
Quito, Ecuador	2812	13	0
Arequipa, Peru	2332	12	16
Chos Malal, Argentina	858	10	37
Punta Arenas, Chile	33	7	53

FIGURE 3.1

LATITUDE, ELEVATION AND TEMPERATURE

IN EURASIA

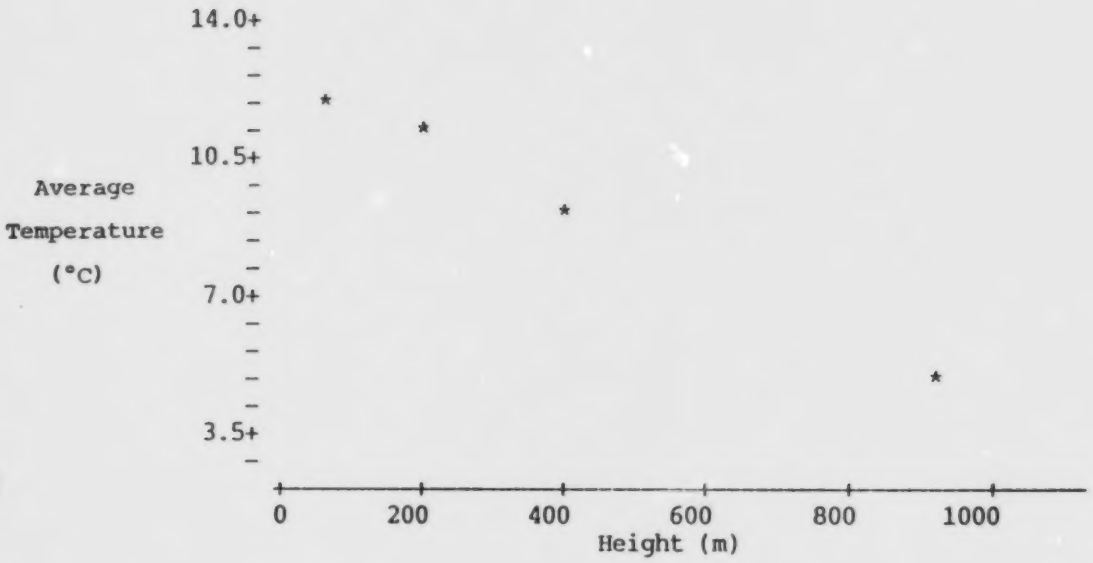


FIGURE 3.2

LATITUDE, ELEVATION AND TEMPERATURE

IN NORTH AMERICA

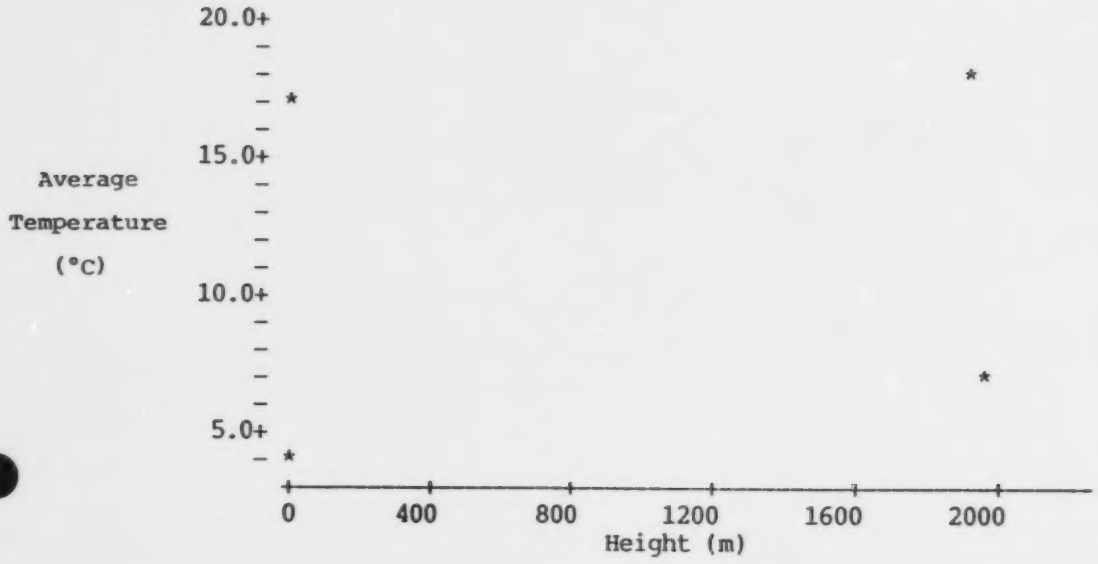


FIGURE 3.3

LATITUDE, ELEVATION AND TEMPERATURE

IN SOUTH AMERICA

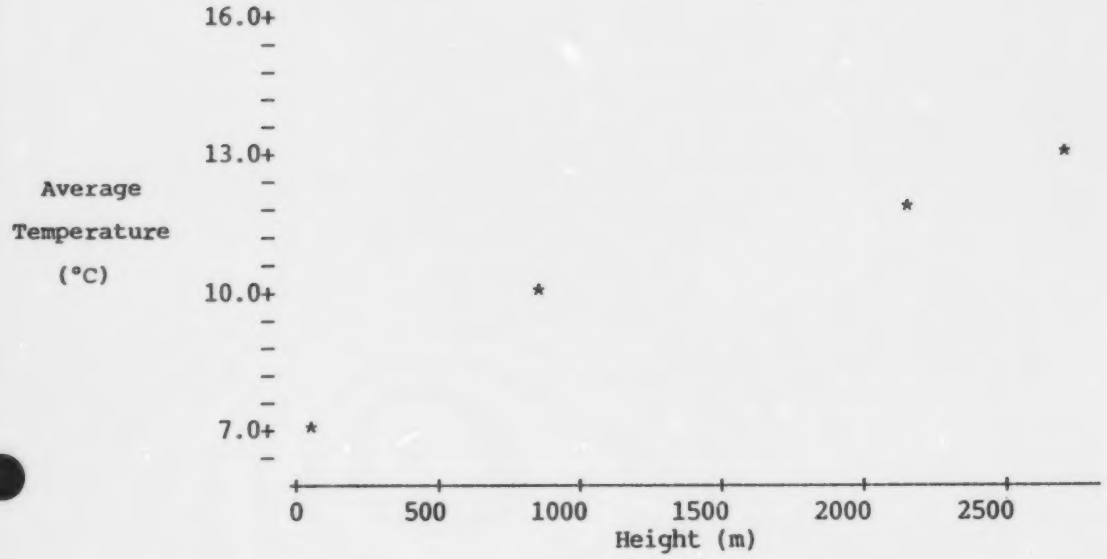


TABLE 3.2a

LATITUDE, ELEVATION AND TEMPERATURE

IN NORTH AMERICA

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (°N)
Ely, Nevada	1909	7	39
San Diego, Ca.	0009	17	33
Asheville, North Carolina	0687	14	34
Grand Junction, Colorado	1475	11	39

FIGURE 3.2a

LATITUDE, ELEVATION AND TEMPERATURE

IN NORTH AMERICA

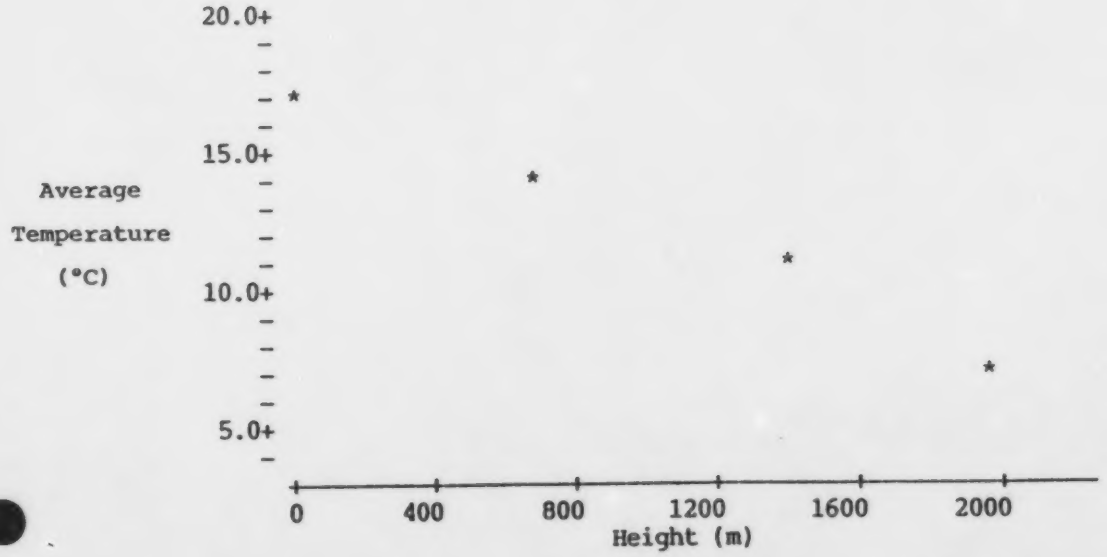


TABLE 3.3a

LATITUDE, ELEVATION AND TEMPERATURE

IN SOUTH AMERICA

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (°S)
Valparaiso, Chile	0041	14	33
Cochabamba, Bolivia	1850	6	17
Chos Malal, Argentina	858	10	37
Salta, Argentina	1182	9	25

FIGURE 3.3a

LATITUDE, ELEVATION AND TEMPERATURE

IN SOUTH AMERICA

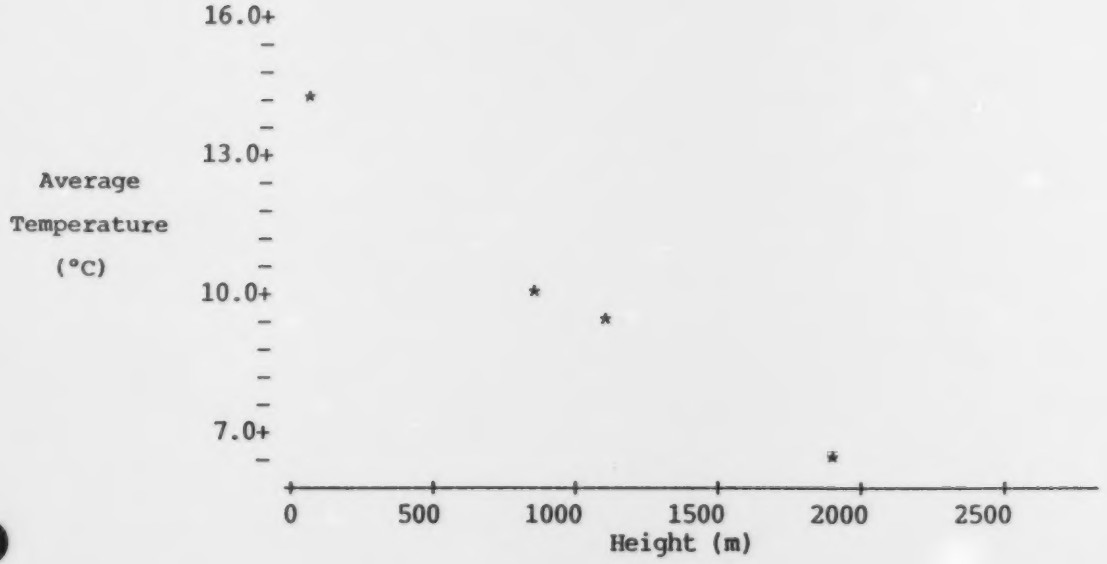


Table 3.4

What is the Missing Variable?

Misleading Results

1. A study found that weight lifters with less than 6 months experience, were able to lift more weight than weight lifters with more than 6 months experience. Should we conclude that there is a negative correlation between experience and amount of weight lifted?

2. A medium size pizza at Lorenzo's costs less than a small pizza at Zeppi's. Should we conclude that there is a negative correlation between pizza size and pizza price?

3. Sarah's has a small dog that rushes to the dog food bowl and gobbles it down in a flash; Heather has a large dog that picks at the food in the bowl. Should we conclude that there is a negative correlation between the size of the dog and the speed of eating dog food?

4. Mrs. Jones has two bushes in front of her driveway. The one that is in the shade is growing very slowly. The other bush is growing very quickly. Should we conclude that there is a negative correlation between growth of bushes and amount of sunlight?

Possible Explanations

1. Large people can lift more than small people so if we want to find out if experience is related to weight lifted, we should keep the size of the competitors the same.

2. More toppings mean a higher price so if we want to know if the size of pizza is related to its cost, keep the number of toppings the same.

3. Heather's dog gets treats all day long; Sarah's doesn't; if we want to know if the size of the dog is related to how quickly the dog eats at supper, keep the number of snacks the same.

4. The quality of the soil affects the growth of bushes. If we want to find out if the growth of bushes is related to amount of sunlight, keep the soil the same.

TABLE 3.5

LATITUDE, TEMPERATURE RANGE , AVERAGE TEMPERATURE, SUNSHINE AND DISTANCE TO WATER FOR PLACES 40-50°N

PLACE NAME	DISTANCE TO LARGE BODIES OF WATER (km)	SUNSHINE (hours)	AVERAGE TEMPERATURE (°C)	TEMPERATURE RANGE (°C)	LATITUDE (°N)
Marseille, France	0000	2791	14	17	43
Krakow, Poland	550	1522	8	22	49
Bordeaux, France	50	2008	12	15	44
Stuttgart, Germany	469	1814	10	19	48
Stratsbourg, France	438	1700	10	19	48
Nimes, France	44	2713	14	18	43
O'Porto, Portugal	0000	2690	14	11	41
Friedrichshafen, Germany	263	1756	9	19	47
Nemuru, Japan	0000	1955	6	24	43
Lyon, France	250	2018	11	19	45
Sault Ste. Marie, Michigan	1273	2163	4	27	46
Urumchi, China	1600	2619	5	40	43

LOCATIONS WITHIN 40-50°N LATITUDE FROM TABLE 3.5

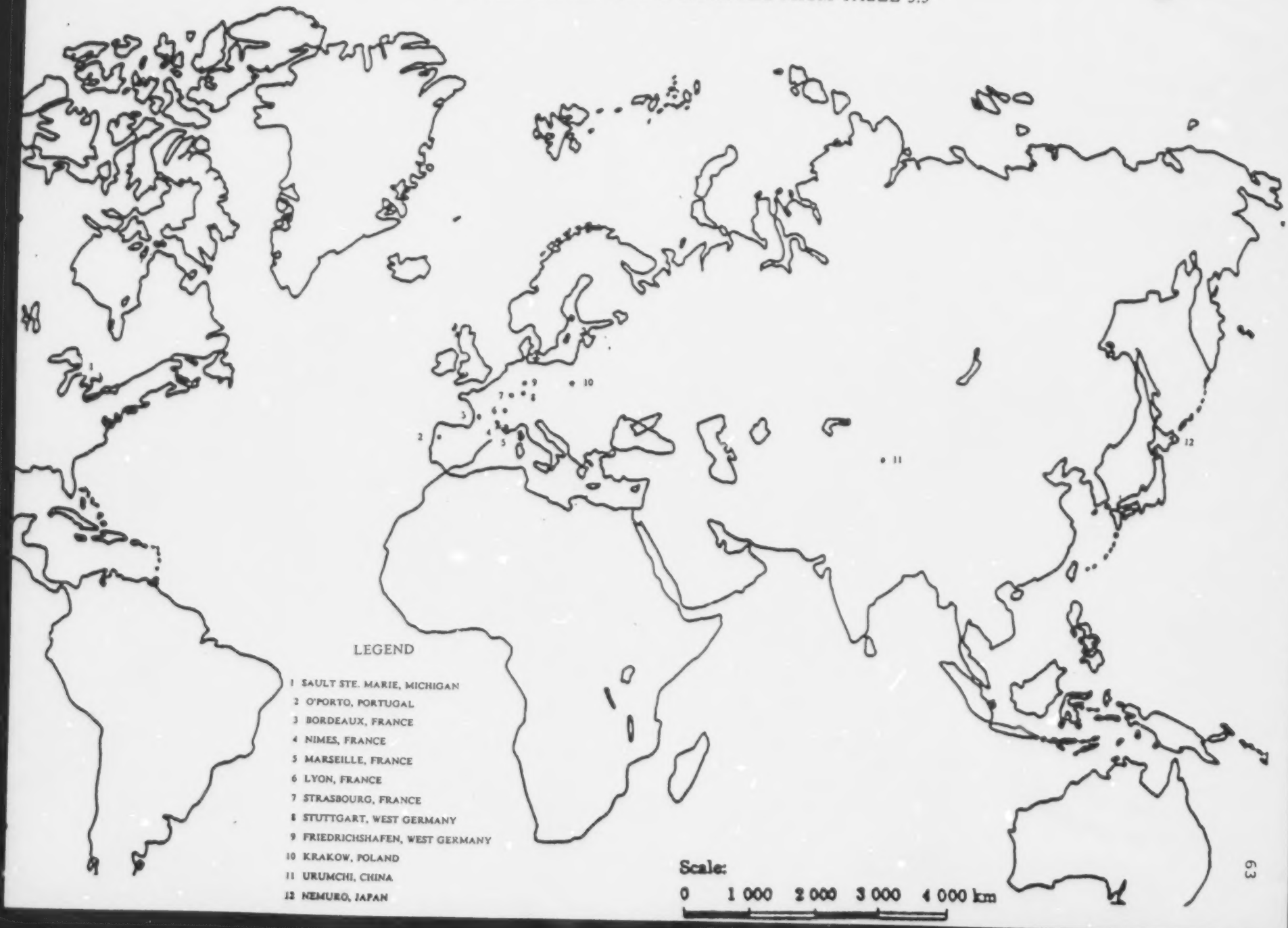


FIGURE 3.5

TEMPERATURE RANGE AND DISTANCE TO LARGE BODIES OF WATER, CONTROLLING FOR LATITUDE (40–50°N)

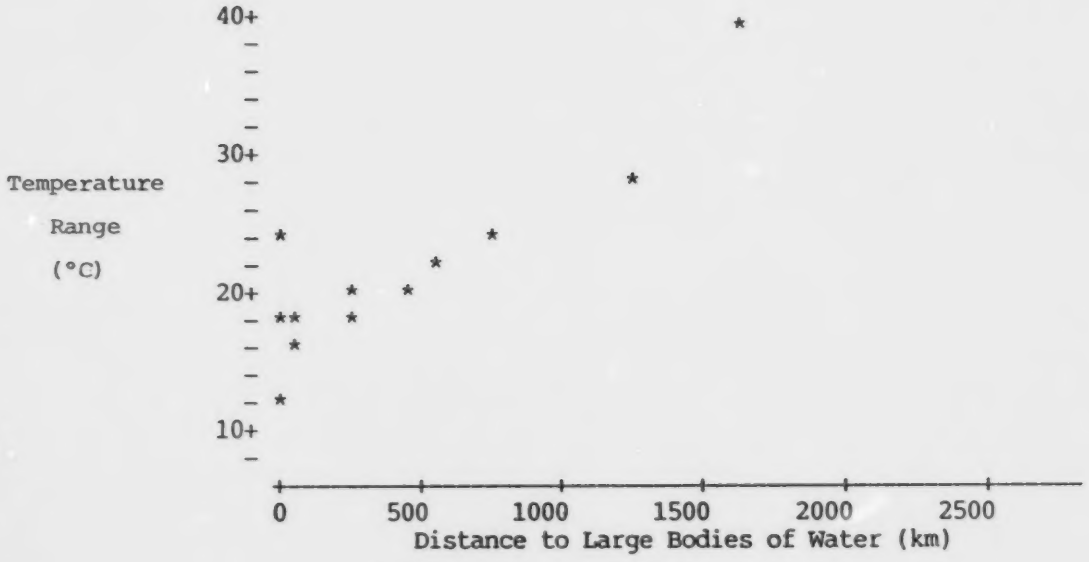


FIGURE 3.6

AVERAGE TEMPERATURE AND DISTANCE TO LARGE BODIES OF WATER, CONTROLLING FOR LATITUDE (40–50°N)

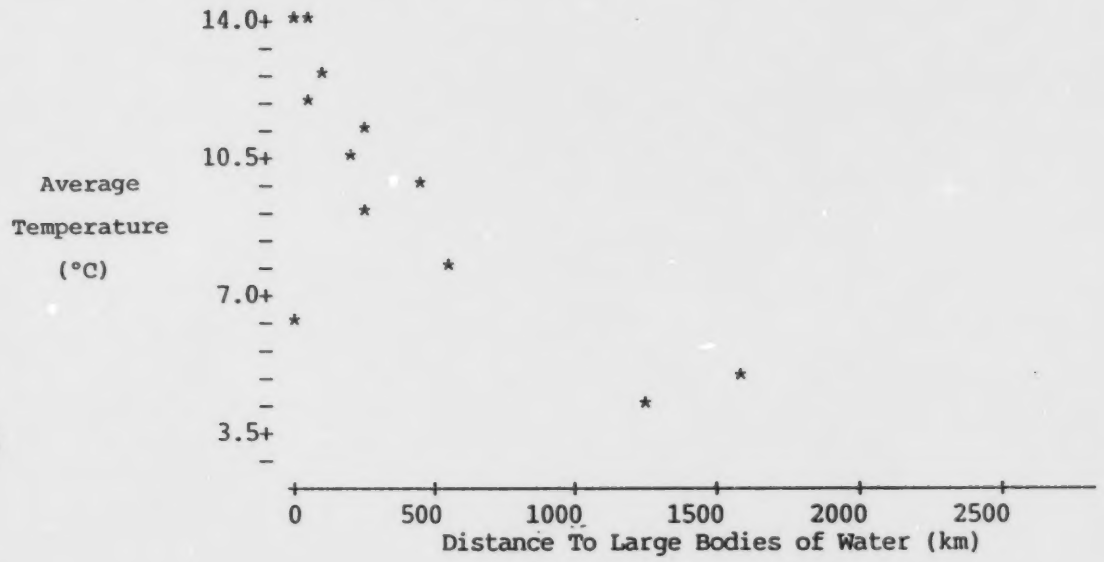


FIGURE 3.7

TEMPERATURE RANGE AND HOURS OF SUNSHINE,
CONTROLLING FOR LATITUDE (40–50°N)

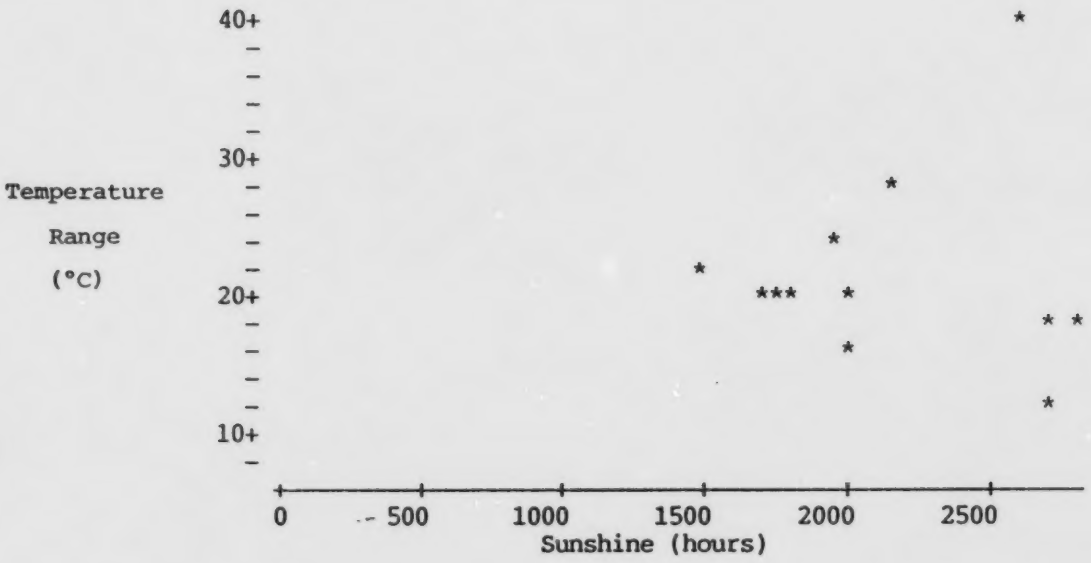
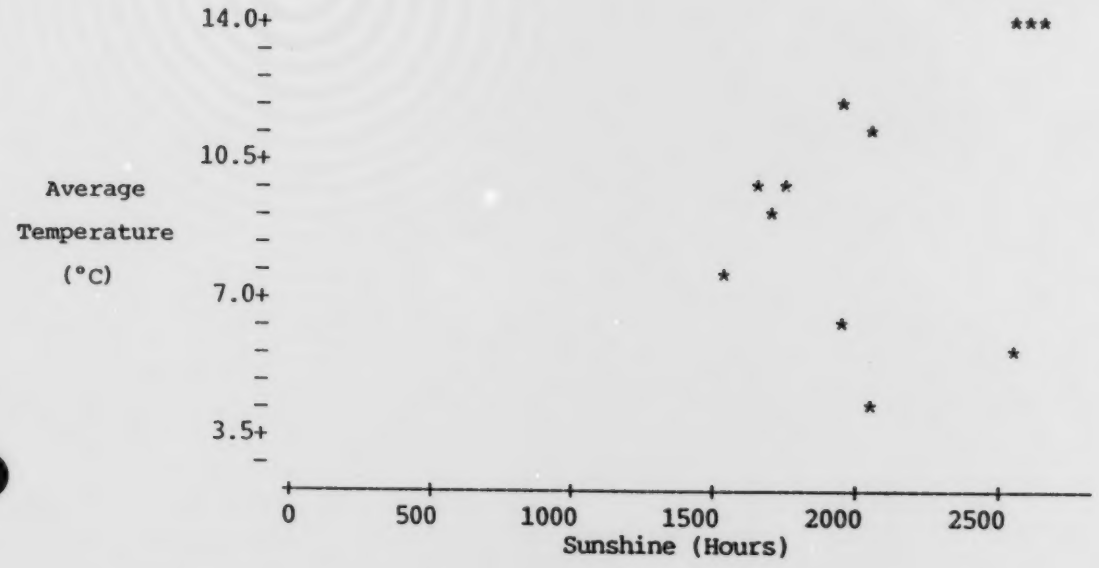


FIGURE 3.8
AVERAGE TEMPERATURE AND HOURS OF SUNSHINE,
CONTROLLING FOR LATITUDE (40–50°N)



QUIZ 2

JACK AND JILL WENT UP THE HILL

Jack and Jill were doing some hiking in Vermont. As they were climbing a fairly steep hill, Jill said, "Brrr, I'm getting cold. Let's turn back, I know it will be warmer once we get to the bottom." Jack said, "Oh come on Jill, don't be such a whimp! Everyone knows that the higher the elevation the warmer the temperature because the closer you are to the sun. By the time we get to the top we'll wish we had worn our Burmuda shorts." "Oh no," said Jill "by the time we get to the top we'll wish we had worn our parkas!"

a) Who was right? Use the information in the table to find out if elevation and temperature are related.

b) What kind of correlation is this?

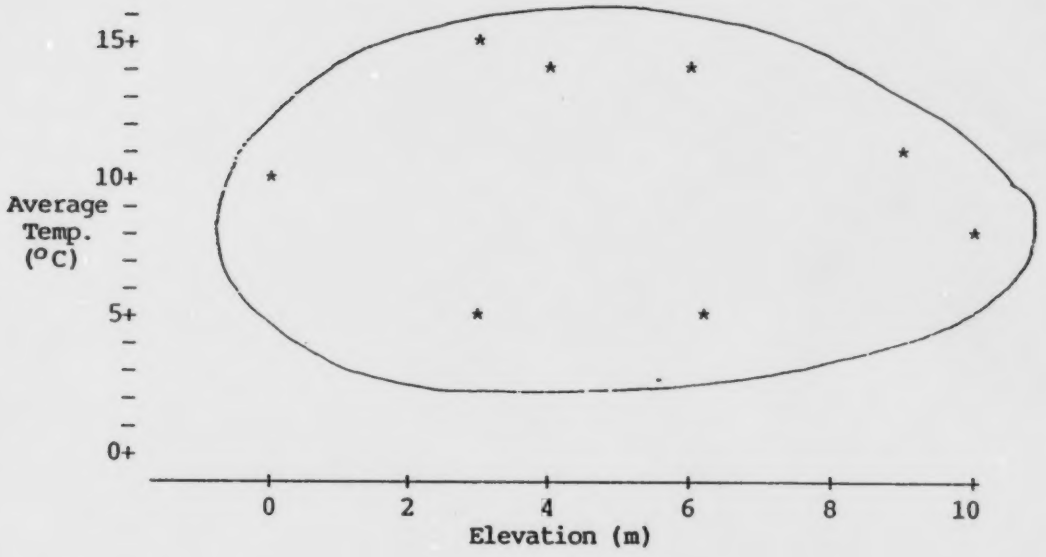
c) What will happen to the temperature, if the elevation goes up?

TEMPERATURE, ELEVATION AND DISTANCE TO LARGE BODIES OF WATER

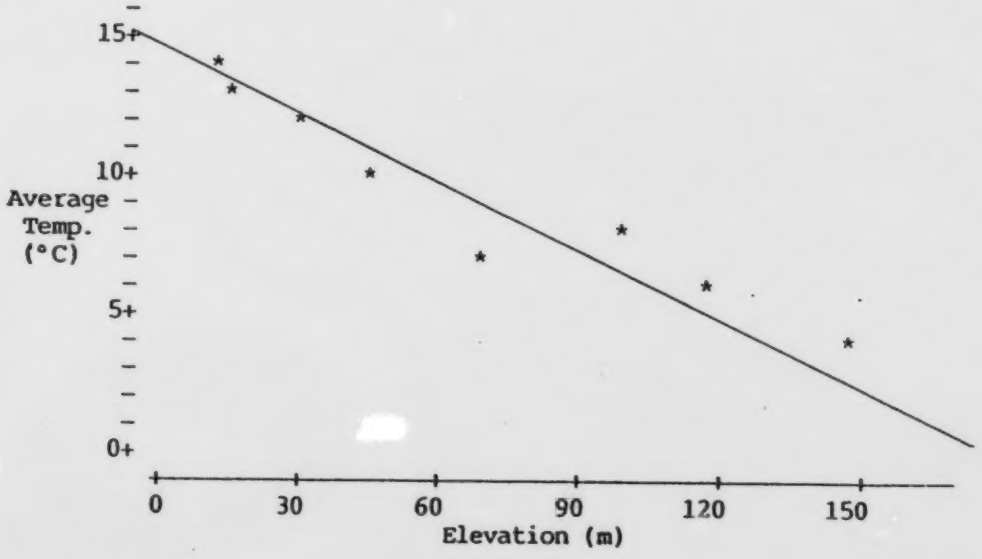
PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	DISTANCE TO LARGE BODIES OF WATER
Gander, Nfld.	147	4	inland
Rize, Turkey	6	14	shoreline
Astrakhan, USSR	18	13	inland
Edirne, Turkey	48	10	inland
Nantucket, Mass.	4	14	shoreline
Canakkale, Turkey	3	15	shoreline
Burlington, Vermont	114	6	inland
Sinuiju, North Korea	6	5	shoreline
Bursa, Turkey	100	8	inland
Portland, Oregon	12	14	inland
Seattle, Washington	10	8	shoreline
Vancouver, B.C.	0	10	shoreline
Asahikawa, China	70	7	inland
Wakkanai, Japan	3	5	shoreline
Montreal, Quebec	30	12	inland
Boston, Mass.	9	11	shoreline

ANSWERS TO QUIZ 2

ELEVATION AND TEMPERATURE FOR PLACES ON THE SHORELINE



ELEVATION AND TEMPERATURE FOR PLACES INLAND



MARKING QUIZ 2

Make a Graph - 10 marks for each graph (20 marks total)

.names each axis	2 marks
.puts in horizontal scale from lowest score (1 mark) to highest score (1 mark) in neat units (1 mark)	3 marks
.puts in vertical scale	3 marks
.labels graph	2 marks

Put Information in the Graph - 5 marks for each graph (10 marks total)

.puts all data in graph correctly (3 marks if one error 1 mark if two errors)	5 marks

Read the Graph - 10 marks total

.draws a line through the cases (2 marks for each graph)	4 marks
.concludes "when elevation goes up, temperature goes down, for inland places; for shoreline places, elevation and temperature are not related (3 marks for correct overall conclusion e.g. "temp goes up when elevation goes up; 2 marks for partially correct conclusion e.g. "for inland places, temp goes up when elevation goes down; for shoreline places temp goes when elevation goes up)	6 marks

MAXIMUM SCORE: 40 MARKS

APPENDIX 4: TEACHER EFFICACY INSTRUMENT

NAME_____ SCHOOL_____
Please Print

TEACHER STYLE SURVEY

Please indicate the degree to which you agree or disagree (1 = Strongly Disagree, 6 = Strongly Agree) with each statement below by circling the appropriate numeral to the right of each statement.

	Strongly Disagree					Strongly Agree
1. When a student does better than usual, many times it is because I exerted a little extra effort.	1	2	3	4	5	6
2. The hours in my class have little influence on students compared to the influence of their home environment.	1	2	3	4	5	6
3. The amount that a student can learn is primarily related to family background.	1	2	3	4	5	6
4. If students aren't disciplined at home, they aren't likely to accept any discipline.	1	2	3	4	5	6
5. When a student is having difficulty with an assignment, I am usually able to adjust it to his/her level.	1	2	3	4	5	6
6. When a student gets a better grade than he/she usually gets, it is usually because I found better ways of teaching that student.	1	2	3	4	5	6
7. When I really try, I can get through to most difficult students.	1	2	3	4	5	6
8. A teacher is very limited in what he/she can achieve because a student's home environment is a large influence on his/her achievement.	1	2	3	4	5	6
9. When the grades of my students improve it is usually because I found more effective teaching approaches.	1	2	3	4	5	6
10. If a student masters a new math concept quickly, this might be because I knew the necessary steps in teaching that concept.	1	2	3	4	5	6
11. If parents would do more with their children, I could do more.	1	2	3	4	5	6
12. If a student did not remember information I gave in a previous lesson, I would know how to increase his/her retention in the next lesson.	1	2	3	4	5	6
13. If a student in my class becomes disruptive and noisy, I feel assured that I know some techniques to redirect him/her quickly.	1	2	3	4	5	6
14. The influence of a student's home experiences can be overcome by good teaching.	1	2	3	4	5	6
15. If one of my students couldn't do a class assignment, I would be able to accurately assess whether the assignment was at the correct level of difficulty.	1	2	3	4	5	6
16. Even a teacher with good teaching abilities may not reach many students.	1	2	3	4	5	6

Name_____ Teacher_____ School_____

STUDENT SURVEY

We want to know what students your age think. There are no right or wrong answers.

There are 23 pairs of statements in this survey. For each pair we want you to **circle the one that you agree with the most.** For some pairs you may disagree with both statements. For others you may agree with both. In each case pick the one that is most like you. Answer quickly because we want your first impressions. Try not to leave any out.

Here is an example:

> **Circle** the statement that you agree with the most.
>
> (a) There is too much emphasis on athletics in this school.
>
> (b) Team sports are an excellent way to build character.

If you think you understand what you are supposed to do, answer the rest of the items. If you have any questions, ask your teacher.

FOR EACH PAIR OF STATEMENTS, CIRCLE THE ONE YOU AGREE WITH THE MOST.

1. (a) Many of the unhappy things in people's lives are partly due to bad luck.

   (b) People's misfortunes result from the mistakes they make.

2. (a) One of the major reasons why we have wars is because people don't take enough interest in politics.

   (b) There will always be wars, no matter how hard people try to prevent them.

3. (a) In the long run people get the respect they deserve in this world.

   (b) Unfortunately, an individual's work often passes unrecognized no matter how hard he tries.

4. (a) The idea that teachers are unfair to students is nonsense.

   (b) Most students don't realize the extent to which their grades are influenced by accidental happenings.

5. (a) Without the right breaks one cannot be an effective leader.

   (b) Capable people who fail to become leaders have not taken advantage of their opportunities.

6. (a) No matter how hard you try some people just don't like you.

(b) People who can't get others to like them don't understand how to get along with others.

7. (a) I have often found that what is going to happen will happen.

(b) Trusting to fate has never turned out as well for me as making a decision to take a definite course of action.

8. (a) In the case of the well prepared student there is rarely if ever such a thing as an unfair test.

(b) Many times exam questions tend to be so unrelated to course work that studying is really useless.

9. (a) Becoming a success is a matter of hard work, luck has little or nothing to do with it.

(b) Getting a good job depends mainly on being in the right place at the right time.

10. (a) The average citizen can have an influence in government decisions.

(b) This world is run by the few people in power, and there is not much the little guy can do about it.

11. (a) When I make plans, I am almost certain that I can make them work.

(b) It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune anyhow.

12. (a) In my case getting what I want has little or nothing to do with luck.

(b) Many times we might just as well decide what to do by flipping a coin.

13. (a) Who gets to be the boss often depends on who was lucky enough to be in the right place first.

(b) Getting people to do the right thing depends upon ability, luck has little or nothing to do with it.

14. (a) As far as world affairs are concerned, most of us are the victims of forces we can neither understand, nor control.

(b) By taking an active part in political and social affairs the people can control world events.

15. (a) Most people don't realize the extent to which their lives are controlled by accidental happenings.

(b) There really is no such thing as "luck".

16. (a) It is hard to know whether or not a person really likes you.

(b) How many friends you have depends on how nice a person you are.

17. (a) In the long run the bad things that happen to us are balanced by the good ones.

(b) Most misfortunes are the result of ability, ignorance, laziness, or all three.

18. (a) With enough effort we can wipe out political corruption.

(b) It is difficult for people to have much control over the things politicians do in office.

19. (a) Sometimes I can't understand how teachers arrive at the grades they give.

(b) There is a direct connection between how hard I study and the grades I get.

20. (a) Many times I feel that I have little influence over the things that happen to me.

(b) It is impossible for me to believe that chance or luck plays an important role in my life.

21. (a) People are lonely because they don't try to be friendly.

(b) There's not much use in trying too hard to please people, if they like you, they like you.

22. (a) What happens to me is my own doing.

(b) Sometimes I feel that I don't have enough control over the direction my life is taking.

23. (a) Most of the time I can't understand why politicians behave the way they do.

(b) In the long run the people are responsible for bad government on a national as well as on a local level.

THE GROUP EMBEDDED FIGURES TEST

ADMINISTRATION

Materials

Stop-watch, test booklets, and a set of sharpened soft black pencils with erasers. Extra pencils should be available.

Directions

Distribute test booklets and pencils. As soon as the identifying information on the cover page has been filled in, the Examiner says: "Now start reading the Directions, which include 2 practice problems for you to do. When you get to the end of the Directions on Page 3, please stop. *Do not* go beyond Page 3." Proctors should circulate in the room making sure subjects are doing the two practice problems correctly and that they do not turn past Page 3.

When all subjects have finished reading the directions on Page 3, E says: "Before I give the signal to start, let me review the points to keep in mind." (Read the statements at the bottom of Page 3, stressing the necessity for tracing all lines of the Simple Form, including the inner lines of the cube, simple form "E," as well as for erasing all incorrect lines.)

"Are there any questions about the directions?" (E should pause to allow questions.) "Raise your hand if you need a new pencil during the test."

E then says: "When I give the signal, turn the page and start the First Section. You will have 2 minutes for the 7 problems in the First Section. Stop when you reach the end of this section. Go ahead!" This section is primarily for practice with the format of the test. Proctors should circulate and give additional explanations to those who seem to be having difficulty with this set of practice items.

After 2 minutes E says: "STOP–Whether you have finished or not. When I give the signal, turn the page and start the Second Section. You will have 5 minutes for the 9 problems in the Second Section. You may not finish all of them, but work as quickly and accurately as you can. Raise your hand if you need a new pencil during the test. Ready, go ahead."

After 5 minutes E says: "STOP–Whether you have finished or not. When I give the signal, turn the page and start the Third Section. You will have 5 minutes for the 9 problems in the Third Section. Raise your hand if you need a new pencil during the test. Ready, go ahead."

After 5 minutes E says: "STOP–Whether you have finished or not. Please close your test booklets."

GROUP EMBEDDED FIGURES TEST

By Philip K. Oltman, Evelyn Raskin, & Herman A. Witkin

Name _____ Sex _____

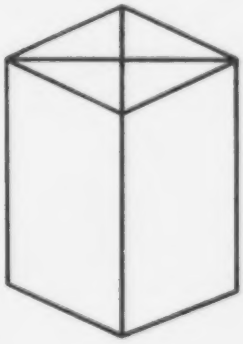
Today's date _____ Birth date _____

INSTRUCTIONS: This is a test of your ability to find a simple form when it is hidden within a complex pattern.

Here is a simple form which we have labeled "X":

X

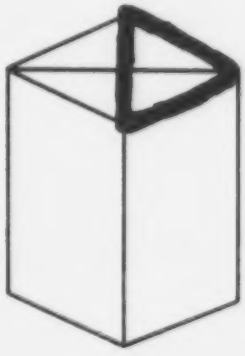
This simple form, named "X", is hidden within the more complex figure below:



Try to find the simple form in the complex figure and trace it *in pencil* directly over the lines of the complex figure. It is the SAME SIZE, in the SAME PROPORTIONS, and FACES IN THE SAME DIRECTION within the complex figure as when it appeared alone.

When you finish, turn the page to check your solution.

This is the correct solution, with the simple form traced over the lines of the complex figure:



Note that the top right-hand triangle is the correct one; the top left-hand triangle is similar, but faces in the opposite direction and is therefore *not* correct.

Now try another practice problem. Find and trace the simple form named "Y" in the complex figure below it:

Look at the next page to check your solution.

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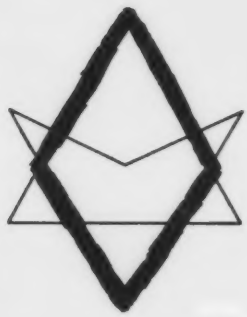
Solution:



In the following pages, problems like the ones above will appear. On each page you will see a complex figure, and under it will be a letter corresponding to the simple form which is hidden in it. For each problem, look at the BACK COVER of this booklet to see which simple form to find. Then try to trace it in pencil over the lines of the complex figure. Note these points:

1. Look back at the simple forms as often as necessary.

2. ERASE ALL MISTAKES.

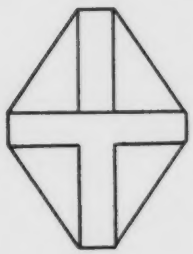
3. Do the problems in order. Don't skip a problem unless you are absolutely "stuck" on it.

4. Trace ONLY ONE SIMPLE FORM IN EACH PROBLEM. You may see more than one, but just trace *one* of them.

5. The simple form is always present in the complex figure in the SAME SIZE, the SAME PROPORTIONS, and FACING IN THE SAME DIRECTION as it appears on the back cover of this booklet.

Do not turn the page until the signal is given

1



Find Simple Form "B"

2

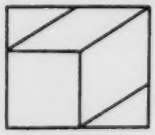
Find Simple Form "G"

Go on to the next page

3

Find Simple Form "D"

4



Find Simple Form "E"

Go on to the next page

5

Find Simple Form "C"

6

Find Simple Form "F"

Go on to the next page

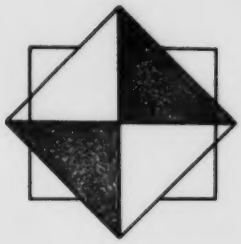
7

Find Simple Form "A"

PLEASE STOP. *Wait for further instructions.*

SECOND SECTION

1



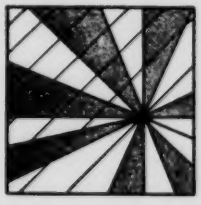
Find Simple Form "G"

2

Find Simple Form "A"

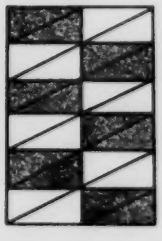
Go on to the next page

3



Find Simple Form "G"

4



Find Simple Form "E"

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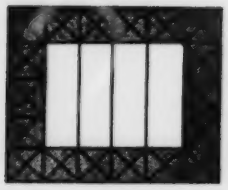
5



Find Simple Form "B"

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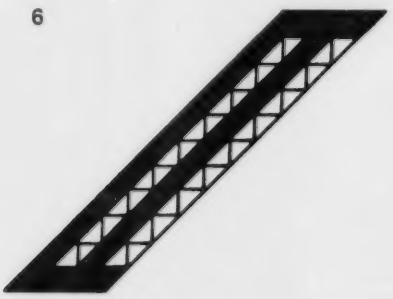

Find Simple Form "C"

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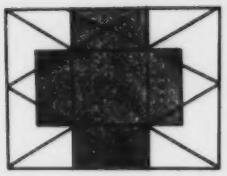
7



Find Simple Form "E"

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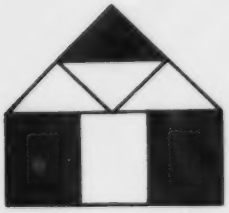


Find Simple Form "D"

Go on to the next page

9

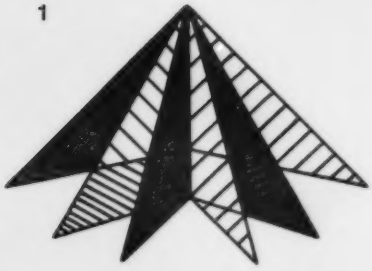
Find Simple Form "H"

PLEASE STOP. *Wait for further instructions.*

21

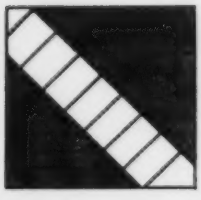
THIRD SECTION

1



Find Simple Form "F"

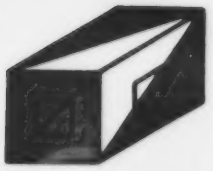
2



Find Simple Form "G"

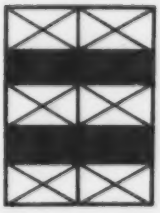
Go on to the next page

3



Find Simple Form "C"

4



Find Simple Form "E"

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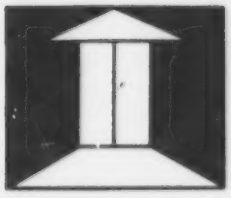
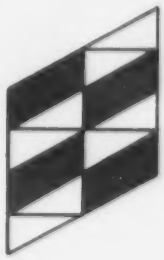
5



Find Simple Form "B"

6



Find Simple Form "E"

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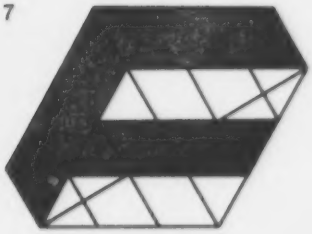
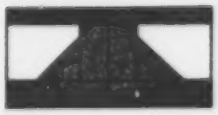
7



Find Simple Form "A"

8



Find Simple Form "C"

Go on to the next page

9

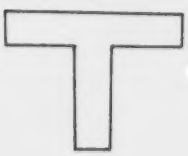
Find Simple Form "A"

PLEASE STOP. *Wait for further instructions.*

SIMPLE FORMS

A

B



C

D

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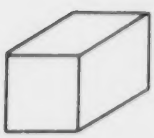

F

G

H

CONSULTING PSYCHOLOGISTS PRESS
577 College Avenue, Palo Alto, California 94306

CORRELATIONAL REASONING MATERIALS

FOR THE

GRADE 9/10 CANADA COURSE

Produced by:

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John Ross:	OISE Trent Valley Centre

Hartland
LOOK, DAD! IT'S RIGHT HERE IN "USA TODAY"! STATISTICS SHOW THAT THE DIVORCE RATE IN THIS COUNTRY IS INCREASING
IN DIRECT CORRELATION WITH THE DECREASE IN THE OCEAN'S WHALE POPULATION!
CAN YOU BELIEVE IT?! D'YA KNOW WHAT THIS MEANS?! D'YA KNOW WHAT THIS TELLS US?! HUH?!
I CERTAINLY DON'T!

DRAFT

MARCH 30, 1990

TEACHER BACKGROUND INFORMATION

The Intermediate/Senior Geography Guideline places a great deal of emphasis on the development of students' correlational reasoning skills, in recognition of the "quantitative revolution" that has been occurring in the discipline over the past two decades. This package provides teaching ideas, practice activities and assessment instruments to help teachers meet Ministry and Board expectations.

Why Teach Correlational Reasoning?

What do geographers do? Consider this definition of the discipline, taken from one of the leading theorists in the field:

> Geography is...a science concerned with the rational development, and testing, of theories that explain and predict the spatial distribution and location of various characteristics on the surface of the earth. (*Geography: A Modern Synthesis*, New York: Harper & Row, 1981)

Expert geographers use many different strategies for finding and testing theories; some of these strategies can be mastered by secondary school students. For example, to find out if there is a relationship between a climate variable (such as rainfall) and another physical variable (such as soil types), the expert geographer might compare two maps, one showing the distribution of rainfall; the other the distribution of soil types (e.g., as shown on pp. 38 and 44 of *Canada and The World*, Scarborough: Prentice Hall, 1985). If the geographer sees similarities between the two maps, he or she concludes that the two variables are related. What is being observed is a correlation: "the degree of association between two or more variables" (*Dictionary of Human Geography*, Southampton: Camelot Press, 1981). This strategy for finding visual correlations can, and is, taught to students.

A closely related approach used by expert geographers is to find statistical as well as visual correlations. In this approach the geographer makes a graph (usually a scatter graph) of the amount of precipitation and the soil types found in a number of locations. By drawing a trend line through the data the geographer is able to see whether the two variables are related. This approach has a number of advantages: some people find it much easier to see a relationship in this form; it takes less time to produce a graph than to construct a choropleth; only a limited number of tones or colours can be shown on a map; statistics can be used to find weak as well as strong relationships, and statistical techniques can be used to find relationships involving more than two variables. This approach to correlational reasoning is rarely taught to students, but it can be, and there is evidence that students can learn these techniques in 3 to 5, 70-minute periods.

Expert geographers differ in how much importance they attach to each approach. "Qualitative" geographers rely more heavily on visual correlations; "quantitative" geographers find the statistical approach more useful. What matters is not whether one is better than the other but that expert geographers are able to do both. The Intermediate/Senior Geography Guideline recognizes the importance of the two approaches toward geographic inquiry by giving equal prominence to the graphing method of finding correlations as it does to the visual techniques.

The graphing method described in this package will be very helpful in meeting the expectations of the Ministry Guidelines for the Canada course and it will provide a firm foundation for Senior Geography. The techniques learned by students here also have application in other subjects, especially math and science, and in handling real life problems (e.g., in discussing environmental issues).

How To Use This Package

The package contains 5 lessons for the Advanced version of the grade 9/10 Canada Course. Each lesson is expected to take one 70 minute period, although classes will vary. lessons 1 and 2 can be done at any time during the year; the content used in the examples and exercises is drawn from issues in Human Geography and everyday life situations. Lesson 3 applies the correlational reasoning skills to Physical Geography problems related to the topic "Agriculture". The activities were designed to be of high interest to students. Teachers may wish to take some class time to discuss the content of the activities after the correlational reasoning objectives have been addressed. The pacing in Lessons 1 to 3 has been designed to meet the needs of typical students. **We suggest that accelerating the pace by omitting some of the practice activities would be unwise.** At the end of these three lessons students should have a good foundation for understanding correlational reasoning and be able to solve a correlational problem involving two variables. Some teachers might want to stop at this point to address other skills and content. All of the geographic data are from the most up-to-date sources available to the committee.

Lessons 4 and 5 provide activities to teach students how to handle correlational problems involving control variables. These lessons are designed to be used at any point in the curriculum. Lessons 4 and 5 are a set. We strongly believe that it would be a waste of class time to teach only one of them. If there is not time for both it would be better to spend the time on other things.

As you look through the package you will notice that we have simplified correlational reasoning so that young secondary students can handle it. This is a new skill for grade 9/10 students and we do not want to go over their heads. For example, we have not said anything about which variable goes on the horizontal axis and which goes on the vertical because the graph will look the same regardless of where the variables go. Also, we decided not to address the notion of causality directly. (However, all of the graphs contained in the package follow the convention of giving the horizontal axis to the independent variable, if one variable can be clearly distinguished as the potential cause and the other the potential effect.)

The text which appears in italics contains suggestions for questions that you might wish to pose to the class, along with examples of student responses where appropriate. We have also included detailed ideas on how to teach the skills. We have colour-coded material intended only for the teacher.

This package is complete, but some teachers (not all) may wish to provide their students with graph paper. In the field test of an earlier version of this material, some teachers found that if students were not given graph paper they would sketch the graph and plot the data more quickly.

Adapting the Package to General Level Courses

Teachers who wish to teach correlational reasoning in the general level version of the Canada course can use this package if adaptations are made.

- Lesson 1 should be expanded to three periods by assigning additional practice activities at the end of steps 4, 5 and 6. For examples of suitable practice exercises see the Grade 7 Unit: **Correlational Reasoning in Climate**; this document can be obtained from the board contacts (Executive Committee members) listed on the cover of this document. In steps 5 and 6 the graphs used in the demonstration might be produced by students prior to being displayed by the teacher.

- Lessons 2 and 3 can be completed in the same sequence. Teachers might limit the number of cases to be plotted in each of the exercises to 10. More attention in Lesson 3 might be given to explaining what a model is.

- Lessons 4 and 5 might be omitted. If they are attempted the same sequence could be followed but at a slower pace.

In the remainder of the introduction you will find: excerpts from the Ministry Guideline, examples of correlational reasoning clipped from newspapers, a summary of growth schemes for the skills addressed in the package, a glossary and a summary of the lessons.

A. Ministry Expectations
Curriculum Guideline Intermediate & Senior 1988

PART A

- Cognitive - Skills Development (page 9)
  - "Teachers must ensure that both cognitive and geographic-skill development are planned for every unit."
- Cognitive - Skills, Table 1 (page 10)
  - The skills listed for inquiry activities are also required in the process of correlational reasoning.
  - Focusing --> Organizing --> Locating --> Recording --> Evaluating --> Synthesizing --> Applying --> Communicating
- Geographic Skills, Growth Chart, Table 2 (page 12)
  - Skill — Progression ---------->

    Charts and Graphs - Derive. . . - Describe. . . - Analyse . . .

PART B

- Skills Objectives (page 3)
  - "Each section or unit provides skills objectives which shall be used in conjunction with the. . . charts. . . . (see appendices).
- Correlation Organizer for Grades 9 & 10 (page 23)
  - ". . .the correlation organizer should be more complex (than for Grades 7 & 8). . . it is suggested that scatter graphs be introduced. . . ."
- Cognitive - Skills Objectives (pages 29-37)
  - References to correlation under **Focus** (page 30) and **Organize** (page 31)

    (Implied references under all other component skills.)
- Geographic - Skills Objectives (pages 38-54)
  - interpret. . . graphs (page 47)
  - interpret. . . information obtained from. . . graphs (page 50)

    (Implied references under other skills.)

PART C

- Program Objectives (page 3)
  - * develop skills in the use of. . . charts, diagrams. . . .
- Geography of Canada (GCA) (pages 29-45)
  - * demonstrate an appropriate level of skill in applying geographic and cognitive skills (page 29)
  - * use. . . graphic forms to. . . communicate (page 29)
  - * use. . . correlation organizers. . . [BG] (page 34)
  - * develop and use. . . causation. . . [A] (page 34)
  - * draw simple. . . graphs. . . [BG] (page 34)
  - * draw complex. . . graphs. . . [A] (page 34)
  - * draw simple. . . graphs [B] . . . complex graphs [AG] (page 41)
  - * becomes familiar with geographic information. . . charts [BGA] (page 43) . . . graphs [GA] (page 43)

B. Hastings County Expectations

Geography Grade 9 GENERAL Level Field Test Program

- applies steps of an inquiry to situations that require a correlation (pages 0-6)
- correlational inquiry, 5 steps and student action (pages 0-19) (to 0-22)
- steps in performing complex skills (pages 1-2)

Geography Grade 9 ADVANCED Level Field Test Program

- constructs a scatter graph for correlational data in everyday problems and geographic problems
- distinguishes between positive correlations, negative correlations and non-correlations in everyday problems and geographic problems
- draws a conclusion based on a trend line on a scatter graph
- describes the relationship between selected variables in everday life and geographic problems
- controls variables in correlational problems

Pollution, breast, colon cancers linked, study says

What's New in Medicine

Marilyn Dunlop

Star June 1/87

A study in 20 Canadian cities has shown an association between acid haze air pollution and breast cancer in women and colon cancer in men and women, according to a report in the Canadian Journal of Public Health.

The study, conducted by three California scientists from data supplied by the Canadian government, found variations in air pollution rates in cities across Canada that co-related with variations in death rates from the two cancers.

Montreal had the highest rates of death from both cancers in women — 22.1 per 100,000 women for colon cancer (compared with 15.1 in Toronto) and 30.7 per 100,000 for breast cancer (25.5 for Toronto). Halifax had the highest rate for men with 24.2 per 100,000 men (18.1 in Toronto).

Dr. Edward Gorham and colleagues found positive association between the rates and two measures of air pollution, sulfur dioxide concentration and haze measurement.

The scientists say the pollution blocks ultraviolet sunlight that is active in producing vitamin D in the skin. There is evidence that vitamin D plays a role in reducing the risk of colon and breast cancer, they say. The evidence includes epidemiology studies that show incidence and death rates from breast and cancer colon is highest in northern cities, and studies in the laboratory that show growth of both kinds of cancer cells can be slowed by vitamin D.

Beer linked to colon cancer

LONDON (Reuter) — Daily beer drinkers are 12 times more at risk of developing cancer of the colon than non-drinkers, a British medical journal said yesterday.

The Lancet said researchers at the Institute of Preventive Oncology in Tokyo found a striking association between alcohol and cancer of the sigmoid colon, part of the large intestine.

A 17-year study found that people who regularly drank alcohol were four times more at risk than tectotallers. But daily beer drinkers were 12 times more likely to develop cancer of the colon than were non-drinkers.

STAR SEPT 23/87

Decaf coffee raises cholesterol: study

NEW ORLEANS (Special) — Science has brewed up another surprise for coffee drinkers: Decaffeinated coffee may be more worrisome to heart patients than regular java, because it raises cholesterol levels.

"We were so surprised," said Dr. Robert Superko of Stanford University, who presented his findings to the American Heart Association meeting here this week.

"We sent samples to another laboratory for independent testing just to be sure we hadn't made some mistake in our lab. The other tests confirmed that something is definitely happening."

The Stanford study monitored the effect of coffee on about 180 men who drank three to six cups each day.

For two months, all the men received a popular brand of regular coffee to drink. After that, they were randomly placed in three different groups, one that continued on regular coffee, one that got decaffeinated and one that abstained from coffee.

CHICAGO TRIB

Hartland

LOOK, DAD!_IT'S RIGHT HERE IN "USA TODAY"! STATISTICS SHOW THAT THE DIVORCE RATE IN THIS COUNTRY IS INCREASING_
_IN DIRECT CORRELATION WITH THE DECREASE IN THE OCEAN'S WHALE POPULATION!
CAN YOU BELIEVE IT?! D'YA KNOW WHAT THIS MEANS?! D'YA KNOW WHAT THIS TELLS US?!_HUH?!_
.I CERTAINLY DON'T!
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Hartland

DAD! DAD!_LOOK AT THIS COLORFUL GRAPH CHART IN "USA TODAY"_IT SHOWS THE CORRELATION BETWEEN THE INCREASED POPULARITY OF DOUBLE-BREASTED TWEED SUITS_
_AND THE DECREASE IN THE AVERAGE LIFE SPAN OF THE GREAT SHOWY OWL!_I MEAN, WOW!!_
_IT'S SO COLORFUL! _SO VIBRANT!_SO DRAMATIC!_SO SO_
MEANINGLESS?
I THINK I'LL CUT IT OUT AND FRAME IT!!
©1988 King Features Syndicate, Inc. World rights reserved

Study links heart attacks to shortness

LONDON (Reuter) — Short men are twice as likely as tall men to have a heart attack in middle age, a British survey indicates.

The lungs of tall men work better and that leads to a healthier heart, says the British Heart Foundation.

Its survey, published yesterday, looked at 1,533 men taller than 5 feet 10 inches and 1,533 men shorter than 5 feet 6 inches, over eight years.

Only 62 of the tall men had heart attacks, while 118 — almost twice the number — of short men had heart attacks.

The shorter men tended to have higher blood pressure and blood cholesterol levels and to smoke more. But "the major factor associated with the extra risk of heart disease in the shorter men appeared to be their poorer lung function."

Mary Walker, co-director of the survey, said short men now have an incentive "to maintain a healthy lifestyle."

Oct. 10/89

STAR

Newsday, L.I. March 24/87

AIDS Data on Women, Birth

State study finds 1 in 77 mothers in city infected with virus

By Laurie Garrett

One of every 77 women who gave birth in New York City last year was infected with the AIDS virus, according to a state Health Department study published today.

Statewide, one of every 150 women was infected, says the report appearing in today's Journal of the American Medical Association.

"I do think this documents what many have suspected, that we have substantial rates of infection among women and newborns," said the lead author, Dr. Lloyd Novick, of the Health Department.

The results parallel a preliminary report in July, based on six months of the study.

The state collected blood samples from all babies born in hospitals, as well as demographic information, but not the names of the mothers. In the year beginning November, 1987, 276,609 blood samples were collected.

During that period, 1,816 babies carried the AIDS virus antibodies, indicating their mothers may have passed on the infection during pregnancy. Using other studies showing that mothers have a 40 percent chance of passing the virus to the fetus, Novick calculated the number of infected mothers.

Using zip codes, Novick's staff also found a correlation between areas of highest AIDS infection and those with the greatest number of drug-related hospital admissions.

"We have no way to know if these mothers used drugs, or whatever," Novick said in an interview. "We can say that since this is concentrated in zip codes of New York City of highest drug use, it is probably related to drug transmission. But it is both through using drugs and being the sexual partners of drug users."

It was always predicted that the heterosexual spread of AIDS would begin among intravenous drug users, said epidemiologist Nancy Padian, of San Francisco General Hospital. "And to my knowledge," she added in an interview, "there really isn't any good data on the number of women who got HIV [the AIDS virus] as a result of sexual exposure alone."

Padian said the state's conclusion that one out of every 150 women who gave birth in New York is infected is a bit misleading because the infections are clearly concentrated in a few key city neighborhoods. In 33 neighborhoods — including Harlem, East Harlem, the South Bronx, East Flatbush, Bedford-Stuyvesant and Jamaica in Queens — the infection rates are two to four times higher than the city average of 1.25 percent of women of childbearing age.

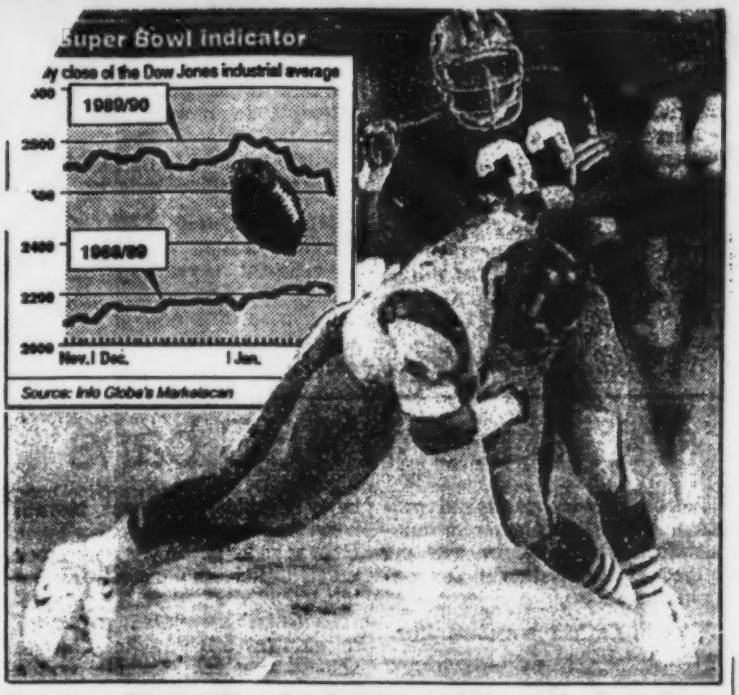
"It's very important to understand," said Padian, "that the bulk of the problem is found in little pockets, neighborhoods."

This "pocketing" of the epidemic makes the public health effort more manageable, said Novick, because AIDS education can be targeted to women in those areas. The educational message, he said, "is that women should be considering AIDS during family planning, plan on being tested for the virus and counseled. We think that has prevention value."

Infection rates among New York babies also vary dramatically along racial lines: for every infected white baby in the city, there are eight black and nearly five Hispanic ones.

Caesarean births linked to size of mother's feet

A small shoe size may be the best indication an expectant mother is likely to have a difficult birth and a caesarean section may be required, according to a British study. A survey of more than 499 births at St. Mary's Hospital, London, found one in five women with a shoe size smaller than 6½ had babies delivered by caesarean section, compared with only one in 100 of those who wore shoes size 8½ or larger. It also found labor was longer for small-footed women, in first and later pregnancies. The study, reported in The Medical Post, found no link between a woman's height and difficult births.



Dow Jones figures indicate San Francisco could fumble the Super Bowl.

Financiers as well as fans see future in Super Bowl

BY FLOYD NORRIS
New York Times Service

EW YORK

There are just four trading days until the Super Bowl is played, and unless share prices rise this week, the outcome could be bad news for San Francisco and for stock buyers.

Or it will be if two Super Bowl indicators work this year, as they did in 1989.

One uses the stock market to forecast the result of the football game. The other uses the result of the football game to forecast the stock market.

There is absolutely no reason to think a football game should have anything to do with the stock market.

But while there are thousands of market indicators, many of which make a lot more sense, few are better known on Wall Street than the Super Bowl theory.

And it is difficult to find one with a better record.

The idea of using the market to forecast the football game is more recent.

It prophesied that if the Dow Jones industrial average rises from the end of November until the game is played, the team whose city falls later in the alphabet will win.

Last year, it correctly predicted that the San Francisco 49ers would beat the Cincinnati Bengals.

That gave the indicator a record of being right in 13 of the past 15 years, failing only in 1982 and 1986.

The Dow was at 2,706.27 at the end of November, 28.37 points higher than its close last week.

Unless it manages to regain that lost ground this week, the market theory forecasts a win by the Denver Broncos over San Francisco.

The much more widely followed Super Bowl indicator holds that a 49ers victory would be a bullish market indicator, because the San Francisco franchise came out of the old National Football League.

A Denver win, on the other hand, would provide a bearish signal, because that team used to be in the American Football League.

Such ideas are, of course, nonsense.

Still, proponents of the theory note that in measuring market performance from Super Bowl to Super Bowl, the theory has failed after only two of the 23 Super Bowl games.

Those failures came after the games in 1970, when a Kansas City (AFL) win was nevertheless followed by a rising year for stocks, and after the 1987 win by the New York Giants, when the October market crash slashed stock prices.

It is, of course, a hallmark of the indicator invention game to change the indicator's rules to produce as good a record as possible.

Both of the failures of the Super Bowl theory can be finessed away by a simple June rule.

In each of the years it failed, it worked from the Super Bowl through the end of June.

In 1970, the market was down 14 per cent from Super Bowl time through June; in 1987, there was a 15 per cent rise over that period.

So the newest version calls for following the indicator and cashing out at the end of June if it worked, while waiting for the next Super Bowl if the market is down as of June.

If that does not work this year, no doubt someone will come up with another modification to prove that in retrospect it really worked again.

One reason for the popularity of the Super Bowl theory is that in recent years the old NFL teams have dominated the game, having won five in a row coming into this week's showdown, and 12 of the past 15.

Sunspots nothing to sneeze at, research finds

BY STEPHEN STRAUSS
The Globe and Mail

When the sun erupts, do people get the sniffles?

Two British researchers have statistically tracked a correlation between solar activity and influenza epidemics stretching back more than 200 years, adding fuel to a controversial thesis first presented more than a decade ago.

In today's issue of Nature magazine, University of Cardiff astronomer Sir Fred Hoyle and mathematician N. C. Wickramsinghe examine the relationship between large outbreaks of the flu and the peak of the 11-year cycle of sun activity.

Called the "solar maximum," this violent period is marked by large numbers of sun spots and frequent magnetic storms producing radioactive solar flares.

While the decade-old research found five instances going back to 1919 of correlation between worldwide flu epidemics and sunspots, the new data carries the connection to 1761. If they ignore three cycles with abnormally low sunspot numbers, the two scientists say, there is a rough correlation between solar activity peaks and the flu.

Part of the roughness may be because sunspot activity often remains intense for two or three years on either side of the peak month. The British scientists suggest that "electrical fields associated with intense solar winds can rapidly drive charged particles of the size of viruses down through the exposed upper atmosphere into the shelter of the lower atmosphere."

They point out in today's paper that while previous efforts to tie sunspots to cyclical Earth phenomona — Atlantic salmon catches, bull stock markets, Australian rabbit reproduction, among others — have broken down after a few solar maximums, the influenza-epidemic connection seems relatively strong.

The significance of the statistical correlation between sun and flu for the present population of Earth is disquieting: the present solar maximum has either just hit or is about to hit its roughly 11-year peak.

The present maximum has already produced one of the largest number of sunspots recorded.

The authors say that "although the new wave of flu and flu-like illness has not assumed pandemic proportions, the chances of this happening within a single complete cycle of terrestrial seasons must be reckoned to be high." Or, it is likely to be a rough winter and spring for flu sufferers.

Fonda buffs like Burger King

SPECIAL TO THE STAR

In a recent U.S. survey, Decision Research Corp. asked people to name their most admired heroes and their favorite food brands. Among the findings, as reported in Advertising Age:

☐ People who admire Sandra Day O'Connor probably drink Coke.

☐ People who admire John F. Kennedy drink Pepsi.

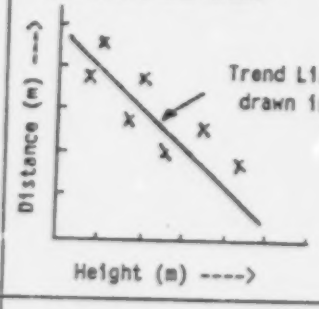
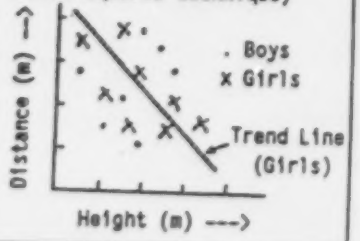
☐ People who admire Jane Fonda, Jesse Jackson or Pete Rose like the fast food at Burger King, but people who admire Abraham Lincoln prefer McDonald's.

The survey offered no analysis.

KNIGHT-RIDDER

GROWTH SCHEME FOR SELECTED SKILLS IN CORRELATIONAL INQUIRY

"DOES HEIGHT AFFECT HOW YOU SWIM?"

	LEVEL 1	LEVEL TWO	LEVEL THREE	LEVEL FOUR
ORGANIZING	NO PRODUCTIVE DISPLAY . does not rearrange data or does so in an unproductive way (e.g. might attempt to average all heights and distances or draw a picture showing superficial features i.e. students swimming)	ORDERING ON 1 VARIABLE . cases are arranged from lowest to highest on one variable (e.g. swimmers listed by height; tables show groupings rather than individual cases)	ORDERING ON 2 VARIABLES . cases are simultaneously arranged from lowest to highest on both variables. Scatter graph(s) used.	DISPLAYS EXPOSING THE INFLUENCE OF CONTROL VARIABLES . cases are ordered on two variables and show the influence of a control variable (e.g. a scatter graph for both girls and boys with distance plotted against height.
LOCATING OR SELECTING DATA	NO DATA LOCATED . no references to empirical cases	RANDOM CASES . a few cases chosen at random	A SELECTION OF CASES . a sample of cases selected based on some principle (e.g. one swimmer from each height grouping or the best and worst performance by males and females)	ENOUGH CASES TO FIND A RELATIONSHIP . enough cases selected to find a strong relationship (e.g. performances by all 18 boys and girls included)
SYNTHESIZING DATA	CRUDE STRATEGIES . makes no attempt to summarize information e.g. data is left in original form NAMES SEX HEIGHT DISTANCE	SIMPLE SUMMARY/STRATEGIES . calculates a simple statistic (e.g. compares means, medians, proportions or percentages Average distance of short swimmers (1.3 m to 1.6 m) is 94 metres Average distance of tall swimmers (1.7 m to 2.0 m) is 87 metres	NON-TECHNICAL REPRESENTATION OF THE TREND . draws a trend line through the plotted points or circles perimeter of points in a way that shows the trend  	TECHNICAL REPRESENTATION OF THE TREND . calculates an appropriate sophisticated statistic (e.g. correlational coefficient r = -.0.933 calculates a trend line (e.g. using the least squares technique) 
DRAWING A CONCLUSION	NO CORRECT RELATIONSHIP . describes no relationship or one that is not true (e.g. girls' swimming improves with height), or a relationship that is irrelevant to the question. (e.g. boys swim faster than girls)	PARTIALLY CORRECT RELATIONSHIP DESCRIBED . relationship for part of data correctly described. (e.g. the taller the boy the less distance he swims)	CORRECT TWO VARIABLE RELATIONSHIP DESCRIBED . describes correct relationships and its direction. (e.g. there is a marked negative correlation between height and swimming in general and for girls in part)	CORRECT 2 VARIABLE RELATIONSHIP EXPLAINED . describes correct relationship and direction between two variables while controlling for a third

HELPFUL DEFINITIONS

A **Correlational problem** is one in which you have to find an association between two or more variables when you cannot physically manipulate the variables.

An **association** is a relationship between two variables such that as one variable changes a pattern can be seen in the changes of another variable.

Positive Correlation: As one variable changes, the other variable changes in the same way. For example, as the number of drinking drivers increases, the number of traffic accidents increases.

Negative Correlation: As one variable changes, the other changes in the opposite way. For example, as the distance from industry goes up, the number of lung disease cases goes down.

Non Correlation: As one variable changes, there is no pattern in the other variable. For example, as the size of cars goes up, the number of accidents goes up, down or stays the same.

Variable: Anything of interest that can change or take different values. For example, the number of drinking drivers in a city is a variable because the number is different in each city.

Organizing is the skill of identifying the elements of the problem and the relationships among these elements.

Locating/selecting data is the skill of choosing data which is relevant to the problem.

Synthesizing is the skill of interpreting relationships within data.

Concluding is the skill of reporting a relationship.

A **scatter graph** plots cases on a grid creating by cross-muliplying two variables.

A **trend line** is a line drawn through the cases on a graph which shows how the variables are related.

A **choropleth map** is a thematic map which uses tonal shadings to show differences.

To **control variables** is to reveal the influence of a hidden variable on a correlation.

GCA 1A1 Correlational Inquiry

Lesson	Outcomes	Strategy/Resources	Evaluation
1	Understand the concept of correlation	Define the concept	
	Be able to organize & interpret correlational data.	Demonstrate 3 step procedure. Practice finding correlations.	Pretest marking scheme
	Be able to distinguish among positive, negative and non-correlations.	Show examples of negative and non-correlations. Practice distinguishing 3 types. Practice finding 3 types.	
2	Be able to organize & interpret correlational data.	Practice finding correlations in geographic data concerning Canada's place in the world.	Quiz 1 marking scheme
3	Be able to solve a connected series of correlational problems.	Practice finding correlations between degree days, precipitation and soya bean production in Ontario. Find correlations between degree days, latitude & elevation. Construct a model of co-op production.	Growth schemes for 4 skills
4	Be able to control variables when organizing & interpreting correlational data.	Demonstrate need to control variables. Practice controlling in correlational problems.	Growth schemes for 4 skills
5	Be able to control variables in correlational problems.	Practice controlling variables in correlational problems.	Quiz 2

Lesson 1

Introduction to Correlation

Outcomes

1. Understand the concept of correlation.
2. Be able to distinguish between positive correlations, negative correlations and non-correlations.
3. Be able to organize and interpret correlational data.

Suggested Teaching Strategy

1. Provide students with **motivation.** For example, direct student attention of the collage of newspaper articles [included in the introduction to the package]. Tell students that the next few days will be spent learning how to solve correlational problems like the ones described in the newspapers. Define the concept:

> *When you put together two things that are changing, to see if they are related, you are looking for a* ***correlation.***

Have students think of examples of correlations, at home or in school. For instance, why do you do better on some tests than others? Could your test scores be related to how hard you studied? or how much you liked the subject? or how you felt the day of the test? Sports is a particularly fruitful source of examples of correlations: do left-handed hockey players score as many points as right-handers? is high jumping related to the jumper's height?

Here is an example

> *Mavis, a grade 9 student, met some friends on the way to school. "Why are you smoking", she said, "Don't you know it causes cancer?" Her friends started to make fun of her, telling her there was nothing to worry about, because there isn't any proof that smoking is bad for your health. But Mavis had a graph (Figure 1.1) that showed there was. "Here is evidence," she said, "as the amount of tobacco consumed in Canada goes up (running her finger along the horizontal axis of the graph), the number of lung disease deaths twenty years later also goes up (running her finger along the vertical axis)."*

2. Demonstrate **how to find a correlation. Present this task:**

> *Parents and teachers are always telling kids that they shouldn't quit school. Some students think that the sooner you are out in the work world the better off you will be. They say that if you hang around in school all the good jobs will be taken. Use the Statistics Canada information in Table 1.2 to find out if staying in school makes a difference to how much money you make.*

Write on the blackboard the main steps in finding a correlation: make a graph; put information into the graph; read the graph. Use the data to illustrate each of the steps.

(i) **Make a graph**

* draw the two axes
* give each axis a name: "Years of Schooling" on the horizontal and "Annual Income" on the vertical

  [TEACHER NOTE: It doesn't matter if this is reversed so that income goes on the vertical: the graph will show the same result.]

* put in a scale for the horizontal axis
  - the scale should begin with the lowest (1 year) and end with the highest (21 years)
  - divide the scale into equal units (units of 4 years)
* put in a scale for the vertical axis
  - the scale should begin with the lowest ($3 200) and end with the highest ($24 300)
  - divide the scale into equal units ($3 000 units)
* give the graph a title ("Years of Schooling And Annual Income")

(ii) **Put information in the graph**

* locate the first case (16 years of schooling) on the horizontal scale (16) and run a ruler straight up
* locate the first case (16 years of schooling) on the vertical scale ($17 500) and run a ruler straight across
* place a small mark where the rulers intersect
* repeat for the rest of the cases

(iii) **Read the graph**

* draw a line that comes as close to each case as possible, with the same number of cases on one side of the line as the other (see Figure 1.3.)
* decide what kind of correlation is shown: Run your finger from left to right along the horizontal axis. *What is happening to income when the number of years of schooling goes up? [Income also goes up.]* Run your finger in the opposite direction along the same axis: *What happens to income when schooling goes down? [Income also goes down.]*

  Tell students that this graph shows a **positive correlation.** It is called a positive correlation because the two things in the graph change in the same way; when one variable in the graph goes up, the other goes up; when one variable goes down, the other goes down.

[TEACHER NOTE: A variable is anything of interest that can change or take different values.]

3. Review the steps in making a graph. Make a poster "How to Find a Correlation" containing the three main steps and the substeps as shown in Section 2 above. This poster should be prominently displayed throughout the correlational reasoning lessons. Students should have a copy in their notebooks.

4. Assign Practice Exercise 1.1. The exercise requires students to plot 21 cases. Teachers may decide to have less able students plot the information for only one Conference or have them plot every second case. In providing feedback to students, focus attention on the three steps of the procedure: make a graph, put information in the graph; read the graph. (The correct answers are given in the exercise answers section. Included in this section is a list of the most common errors committed by students when they are making graphs.)

5. Show students an example of a **negative correlation**. Present the following situation:

> *Jason, a grade 9 student, was telling his friends that he wasn't sure if he was going to be able to get his driver's licence. "What's the point? I'll never be able to afford the insurance! It's really not fair. I have several friends who have been driving for two or three years and none of them have been in an accident."*

Is it fair? Show students the graph in Figure 1.4 which contains information on the relationship between age and number of traffic accidents in which the driver was charged. Ask students, *How is the line in this graph different from those shown before. [It is going in the opposite direction.]* Illustrate the relationship shown in the graph by running your finger up and down the line. Select points on the line--the points chosen do not need to be the cases shown by the asterisks). *What happens to the number of accidents when the age of the driver goes up from 20 years to 50 years? [The number of accidents goes down from 11 to 4] What happens when the age of the driver goes down from 75 years to 35 years? [The number of accidents goes up from 0 to 8] The previous graphs were called positive correlations. What kind of correlation do you think this might be (a* ***negative correlation****).*

> [TEACHER NOTE: Some teachers might wish to give students an exercise in which they would practice finding a negative correlation before proceeding to the third type.]

6. Provide an example of a **non-correlation**. Present the following situation:

> *Stacey and Darren are avid baseball fans but they disagree on the best kind of player to have on the team. Darren thinks that it's best to "go for the long ball." The players should try to hit lots of home runs. Stacey has a different view. She says that the players should "play for one run": hit singles; take walks; steal bases and move the runner over. Who is right? They decided to make a graph using their favourite teams from each league.*

Show students Figure 1.5, containing the results from 1989 for their favourite teams.

Have a student draw a straight line as close to the cases as possible. *Does the line show a negative or a positive correlation? Is it possible to draw a different line that is just as good?* Ask a student to draw a new line; then repeat with other students. Figure 1.6 shows four different ways of drawing the line through these data. Each line is equally good in that each meets the two criteria for drawing a trend line: get as close as you can to each of the cases and make sure there are equal cases on both sides of the line (see Figure 1.5). But none of the lines are very good.

- in graph (a) Pittsburg and Cleveland are a long way from the line;

- in graph (b) Pittsburg and Cleveland are OK but Chicago and Cincinatti are a long way from the line;

- in graph (c) and graph (d) none of the teams are a long way from the line but none are close to the line either.

Point out that what is different about this graph is that no single line is any better than the rest. *In all the other examples there was one straight line that showed how the variables were related. In this graph no single line will do because the variables are not related: as home runs go up, winning percentage may go up or down or not change; as home runs go down, winning percentage may go up or down or not change. When two variables are not related it is called a* ***non-correlation****. This is shown by drawing a circle around all of the cases, as shown in Figure 1.6.*

[TEACHER NOTE: Some teachers might wish to give students an exercise in which they would practice finding a non-correlation before proceeding to step 7 in which they have to classify examples of correlations into the three types.]

Table 7 shows the three types of correlation.

7. Assign homework. Each student should do these two tasks:

(a) Read Exercises 1.2, 1.3 and 1.4. For each exercise the student should predict whether the relationship will be a positive, negative or non-correlation.

(b) Select one of the exercises. For this one exercise only, use the information given to find out if your prediction is correct.

[TEACHER NOTE: Less able students should plot all the information if they select Exercise 1.3; if they select Exercise 1.2 or Exercise 1.4 they should plot every second case.]

Evaluation

The homework will be taken up in Lesson 2.

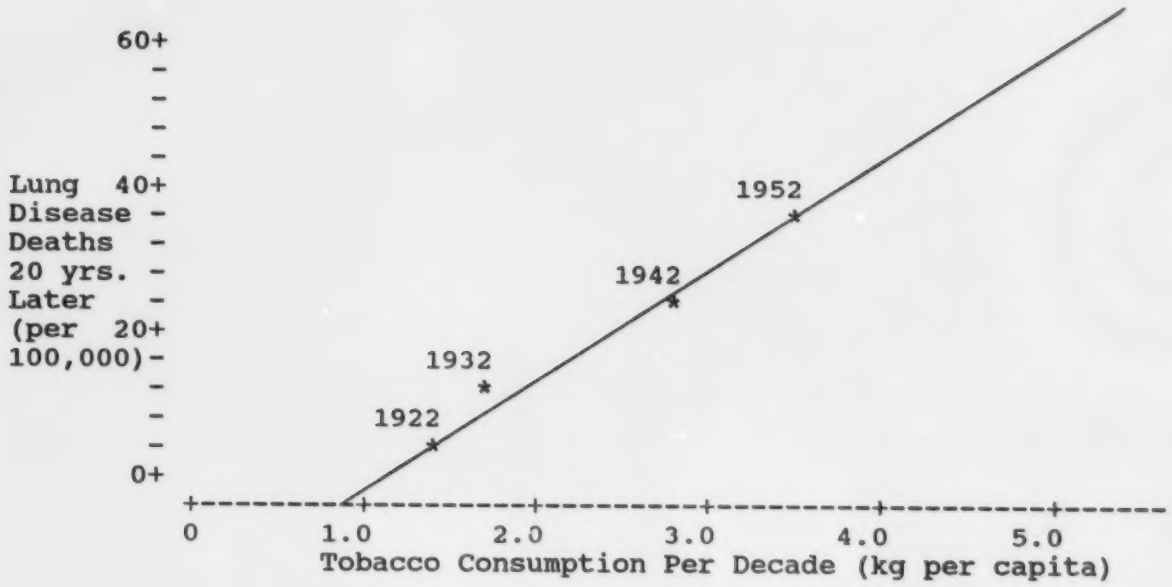
TABLE 1.1

TOBACCO CONSUMPTION AND LUNG DISEASE DEATHS TWENTY YEARS LATER

YEAR	TOBACCO CONSUMPTION PER DECADE (kg per capita)	NUMBER OF LUNG DISEASE DEATHS 20 YEARS LATER (PER 100,000)
1922	1.4	4
1932	1.7	12
1942	2.8	24
1952	3.5	36

FIGURE 1.1

TOBACCO CONSUMPTION AND LUNG DISEASE DEATHS TWENTY YEARS LATER



Poster: How to Find a Correlation

1. **MAKE A GRAPH**
   - draw the two axes
   - give each axis a name
   - put in a scale for the horizontal axis: begin with the lowest score and end with the highest
   - divide the scale into units
   - put in the vertical scale
   - give the graph a title

2. **PUT INFORMATION IN THE GRAPH**
   - locate the first case on the horizontal; run a ruler straight up
   - locate the first case on the vertical; run a ruler straight across
   - place a small mark where the rulers intersect
   - repeat for the rest of the cases

3. **READ THE GRAPH**
   - draw a line that comes as close to each case as possible
   - decide the kind of correlation

Figure 1.3

Years of Schooling and Annual Income

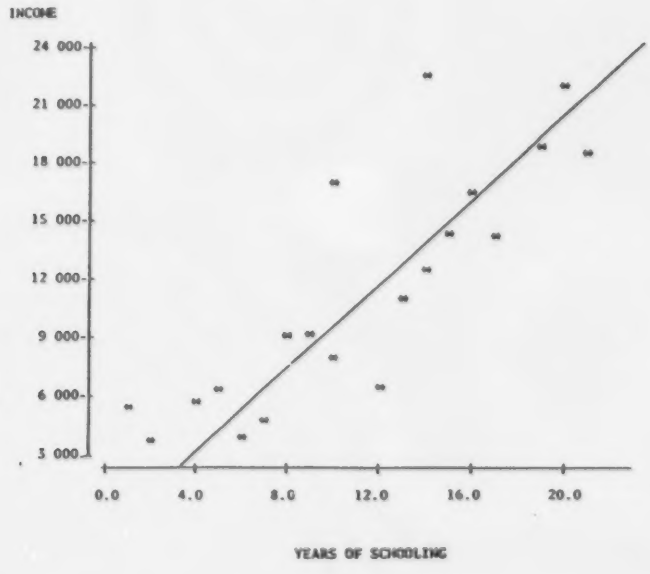


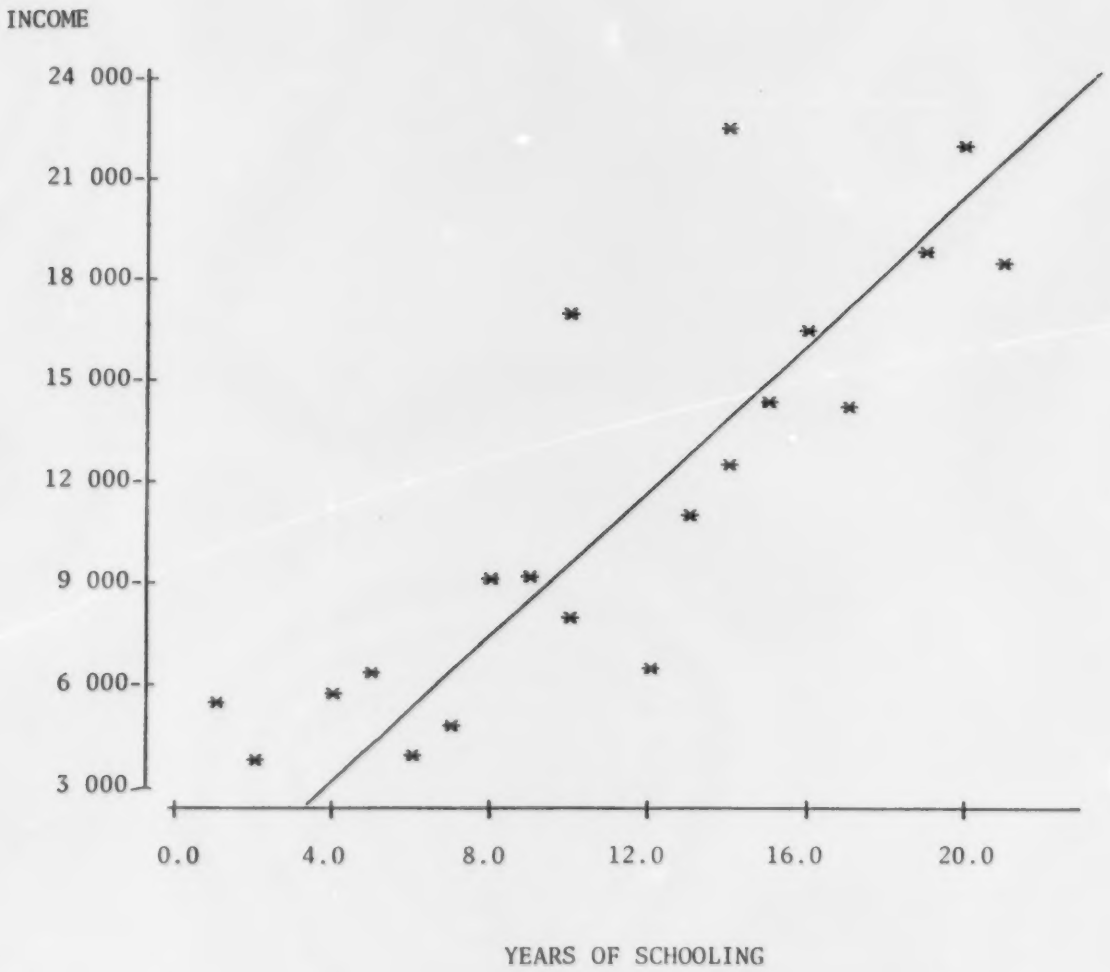
Table 1.2

Years of Schooling and Annual Income

Years of Schooling	Annual Income
16	$17 500
4	5 329
7	4 217
10	18 110
20	23 700
13	11 299
2	3 110
14	24 300
9	9 229
21	19 739
15	15 100
19	20 150
5	6 000
8	9 135
12	6 200
6	3 200
10	7 830
14	13 000
1	5 000
17	15 000

Figure 1.3

Years of Schooling and Annual Income



[f:\corunit/figure1.3]

Exercise 1.1

Winning On The Road

"Winning on the road", said the old coach, wiping the spittle from his chin, "that's what makes for a great team. Anybody can win at home, where your fans are cheering you on. But it's completely different on the road. You're staying in a dreary hotel; it's an unfamiliar rink; all the fans hate you and the home team brings their own ref. Only the great teams have a good road record."

Is the old coach right? Use the information from the 1988-89 NHL season to find out if there is a relationship between away games won and total points.

1988-89 HOCKEY LEAGUE STANDING

FINAL STANDING

WALES CONFERENCE

PATRICK DIVISION	Away Games Won	Points
Washington	16	92
Pittsburgh	16	87
N.Y. Rangers	16	82
Philadelphia	14	80
New Jersey	10	66
N.Y. Islanders	9	61

ADAMS DIVISION	Away Games Won	Points
Montreal	23	115
Boston	20	88
Buffalo	13	83
Hartford	16	79
Quebec	11	61

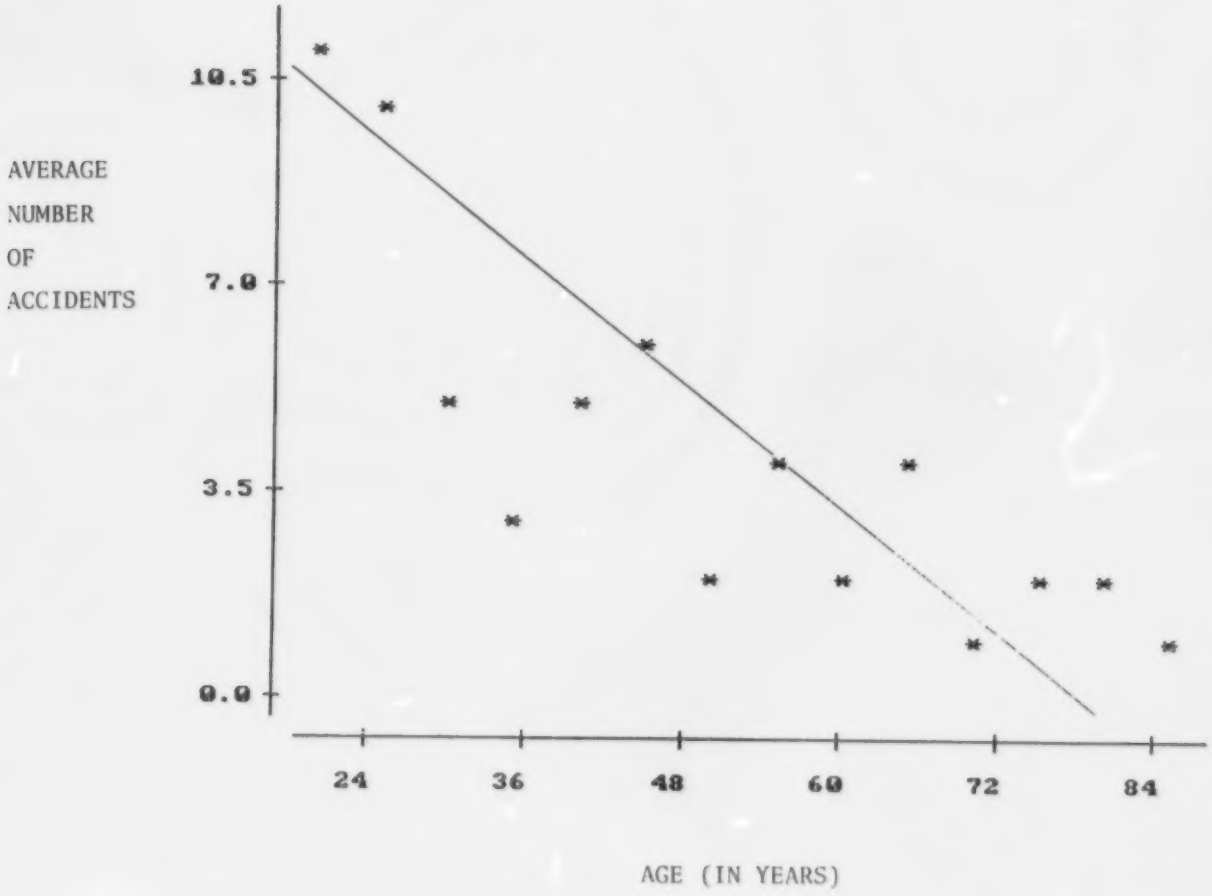
CAMPBELL CONFERENCE

NORRIS DIVISION	Away Games Won	Points
Detroit	14	80
St. Louis	11	78
Minnesota	10	70
Chicago	11	66
Toronto	13	62

SMYTHE DIVISION	Away Games Won	Points
Calgary	22	117
Los Angeles	17	91
Edmonton	17	84
Vancouver	14	74
Winnipeg	9	64

Figure 1.4

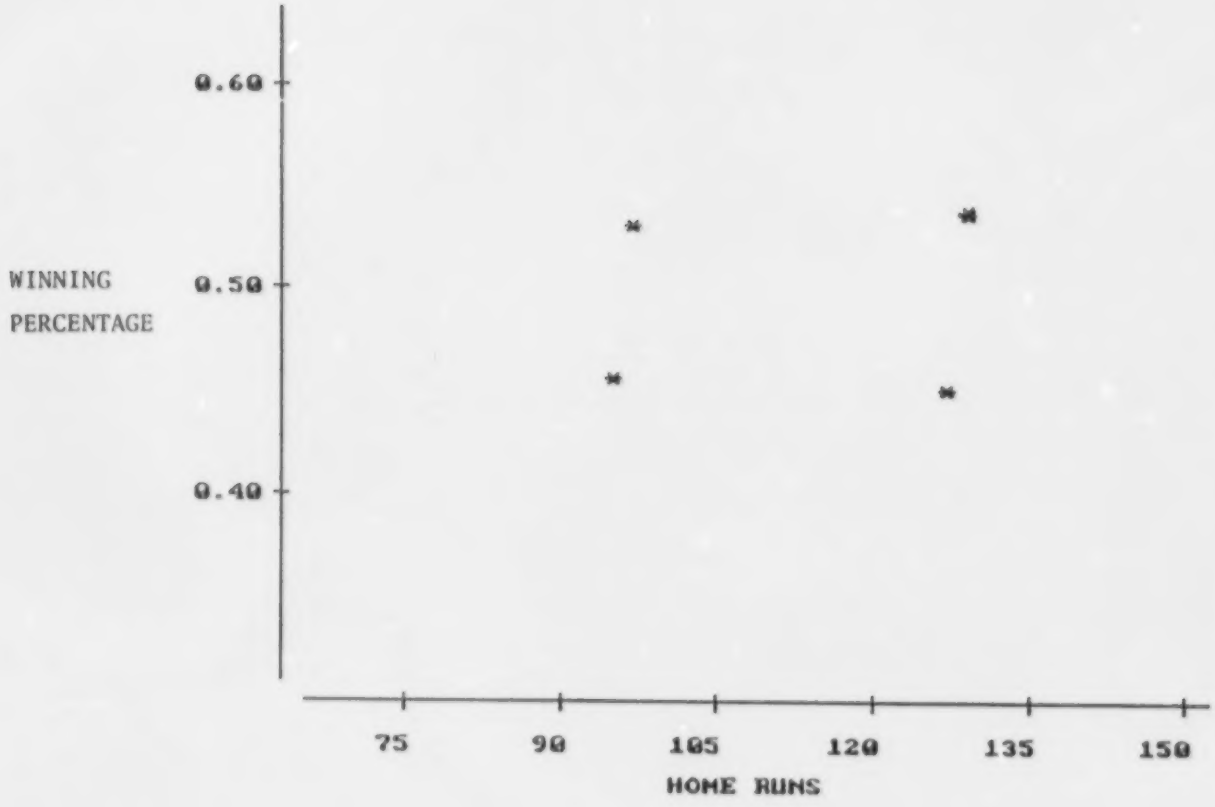
Age and Average Number of Traffic Accidents For Which Charges Were Laid, Belleville, May 1989



[f:\corunit/figure1.4]

Figure 1.5

Baseball 1989
American and National Leagues Combined
Home Runs and Winning Percentage

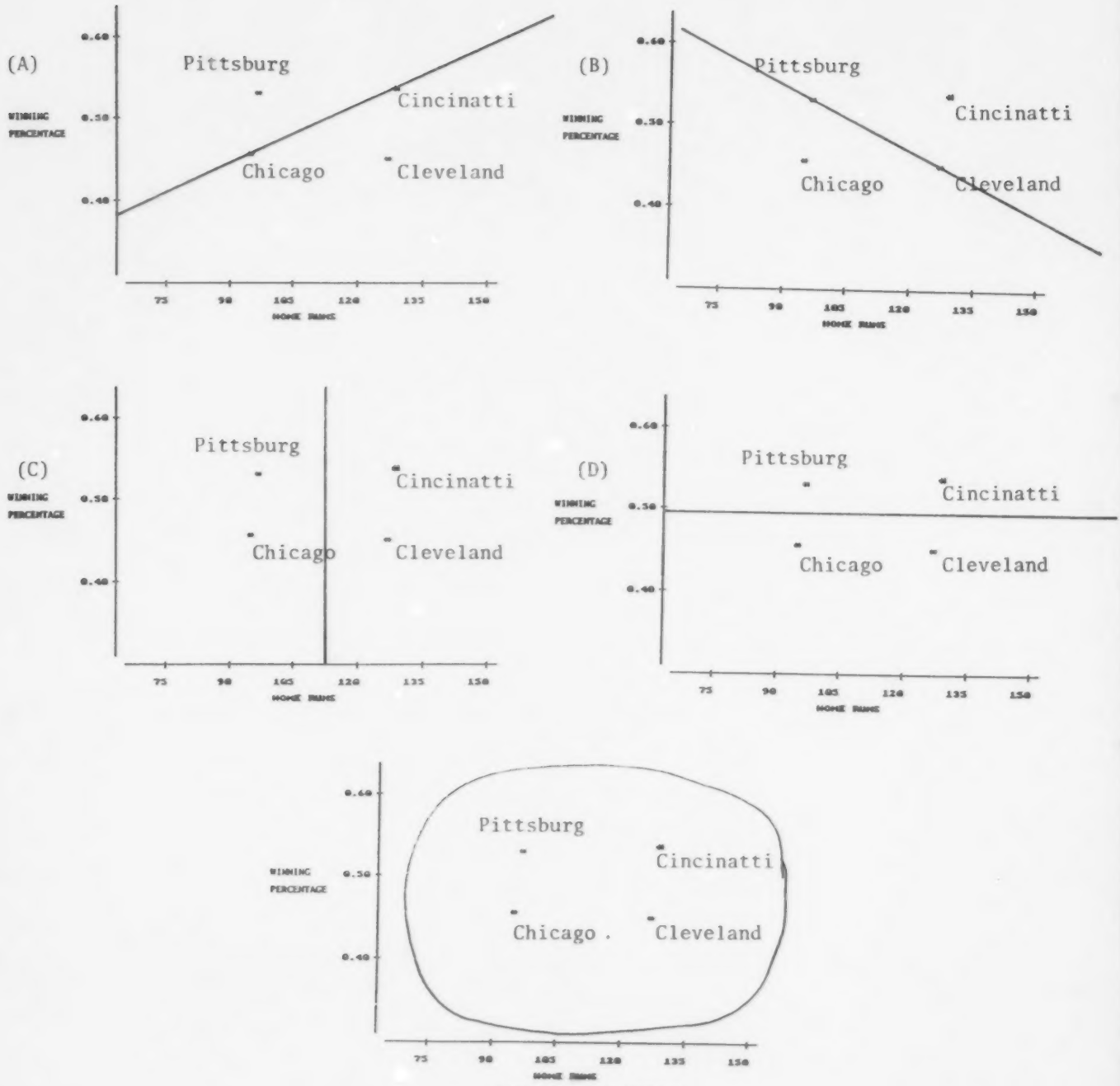


	Winning Percentage	Home Runs
Darren's Teams		
Cleveland Indians	.451	127
Cincinnati Reds	.463	128
Stacey's Teams		
Chicago White Sox	.429	94
Pittsburg Pirates	.457	95

[f:\corunit\figure1.5]

Figure 1.6

Different Ways of Showing the Trend in a Non-Correlation

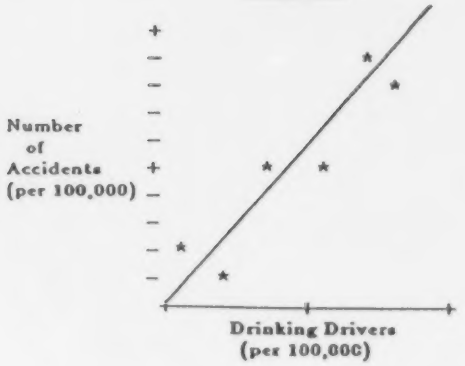
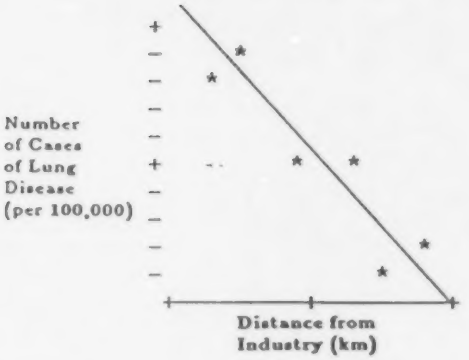
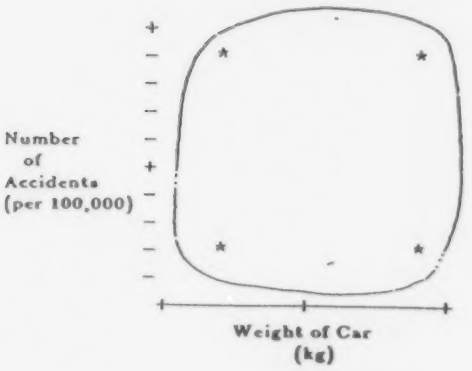


NON-CORRELATION

[f:\corunit\figure1.6]

Table 1.7

Types of Correlations

Type	Example	Definition
Positive Correlation		as one variable changes, the other changes in the same way
Negative Correlation		as one variable changes, the other changes in the opposite way
Non-Correlation		as one variable changes, there is no pattern in the other factor

Exercise 1.2

Allowance and Movies

Jansen and Allison were sitting in their school cafeteria with a group of friends. They were discussing some of the movies they had seen in the theatres during the past year. As they were talking, Allison said:

> *Jansen, you're really lucky; you've seen almost all the good movies this year. You must get a big allowance.*

Jansen replied:

> *I get 17 bucks a week. I think I saw twelve movies at the Star. There are some kids I know who don't get as much money but they've seen a lot more movies.*

Allison and Jansen collected information on weekly allowance and number of movies attended. Video rentals were not included. Use the information in the table to find out if weekly allowance is related to the number of movies seen.

Remember to:

.make a graph
.put information in the graph
.read the graph

	Weekly Allowance	Annual Number of Visits to the Movies
1. Allison J.	$ 5.00	15
2. Melissa	10.00	5
3. Sonja	5.00	20
4. Allison H.	5.00	20
5. Tyla	5.00	27
6. Cathy	0.00	5
7. Andrea	0.00	15
8. Laurie	10.00	10
9. Candice	0.00	10
10. Susan	8.40	25
11. Michelle	5.00	30
12. Melissa	0.00	30
13. Kim	10.00	30
14. Maureen	10.00	20
15. Bill J.	10.00	0
16. Jansen	17.00	12
17. Steve M.	25.00	15
18. Mike	5.00	20
19. Robert	0.00	3
20. Andre	0.00	10

Exercise 1.3

John and Ralph are the fathers of teenagers who have just learned to drive. They are discussing the driving habits of teenagers. John says,

> *The law should make new young drivers drive more slowly than experienced older drivers. One of those crazy kids zoomed by and nearly sideswiped me yesterday.*

Ralph replies:

> *Many young kids are good drivers; they observe the speed limits better than a lot of adults.*

Do young drivers get more speeding tickets than older drivers?

Use the information in the table below. Remember to make a graph, put information in the graph and read the graph.

Speeding Tickets Issued by Belleville Police Force - May 1989

Age	Total Number of Speeding Tickets
18	20
23	20
28	14
33	13
38	15
43	12
48	3
53	6
58	3
67	0
68	2

Exercise 1.4

Age and Cancer

Use the information in the chart to find out if age is related to the number of new cancer cases.

Number of Newly Diagnosed Cases of Cancer Over 5 Years, by Age and Sex for the Hastings County, 1982-1986

Age	Total Cancer Cases
27	15
32	27
37	33
42	64
47	90
52	153
57	206
62	324
67	349
72	369

LESSON 1

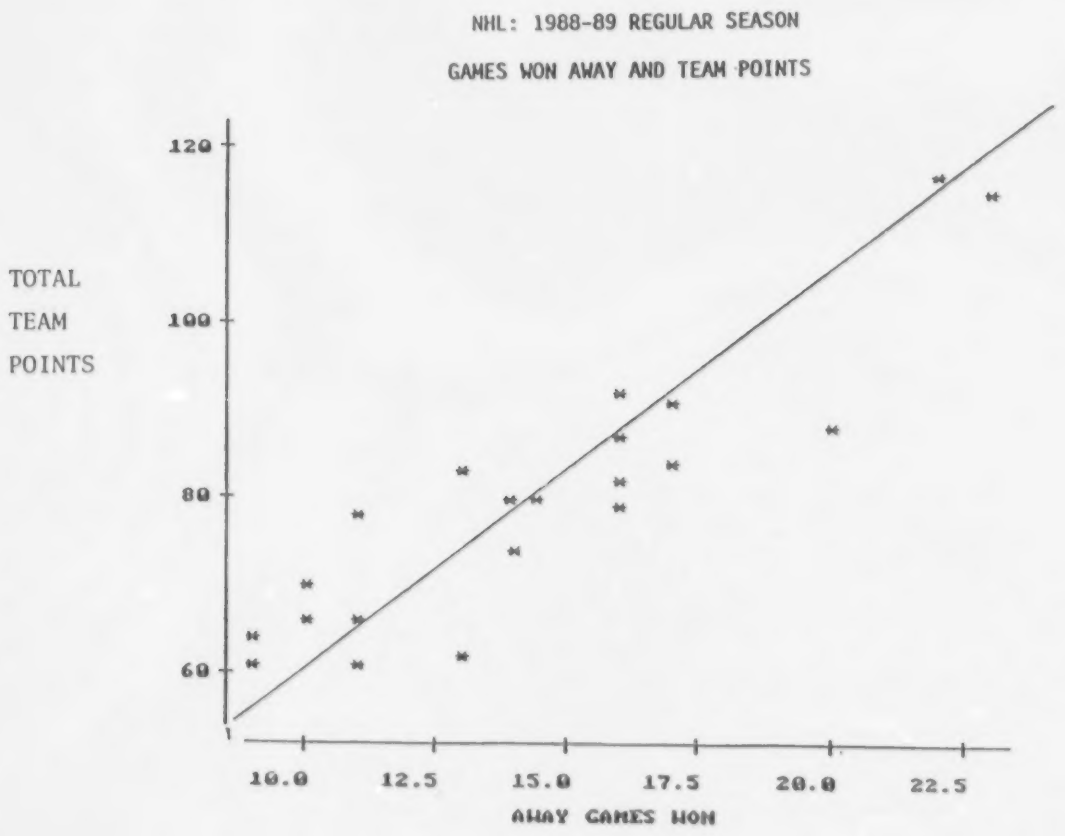
ANSWER SECTION

Answer To Exercise 1.1

The graph shows a positive correlation. As the number of away games won increases, the number of total points also increase. The coach is right.

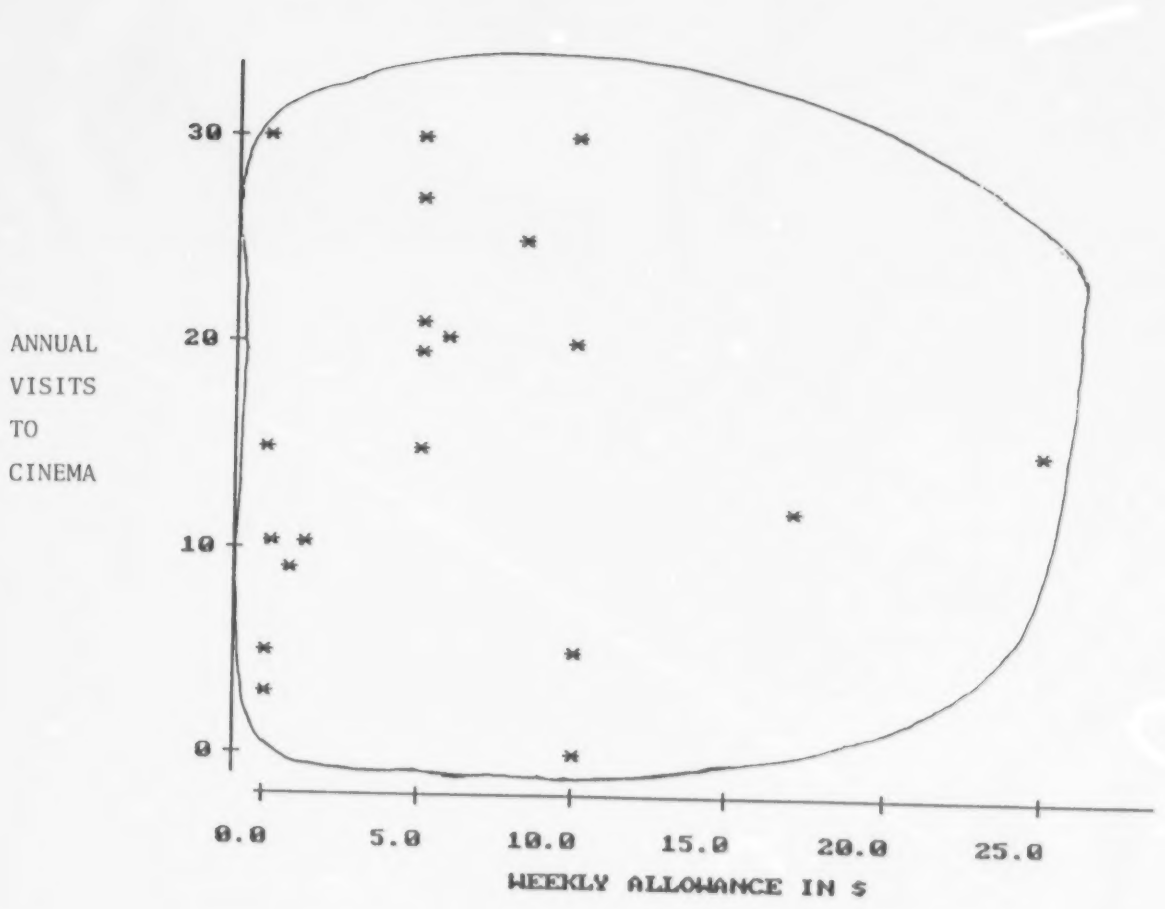
List of Common Errors Made by Students in Graphing

1. The student puts the cases on the graph in the order in which they appear in the table so that the horizontal scale reads 16, 14, 10, 9, 23, etc.
2. The student puts the horizontal scale in the right order, but the spacing is not right.
3. The horizontal axis and the vertical axis, or the graph as a whole, are not properly labelled.
4. The student connects the points in the graph using a series of lines or a curved line, rather than drawing a straight line through them.
5. The student does not extend the line beyond the cases given (which makes it harder to predict new cases from the graph).



Answer to Exercise 1.2

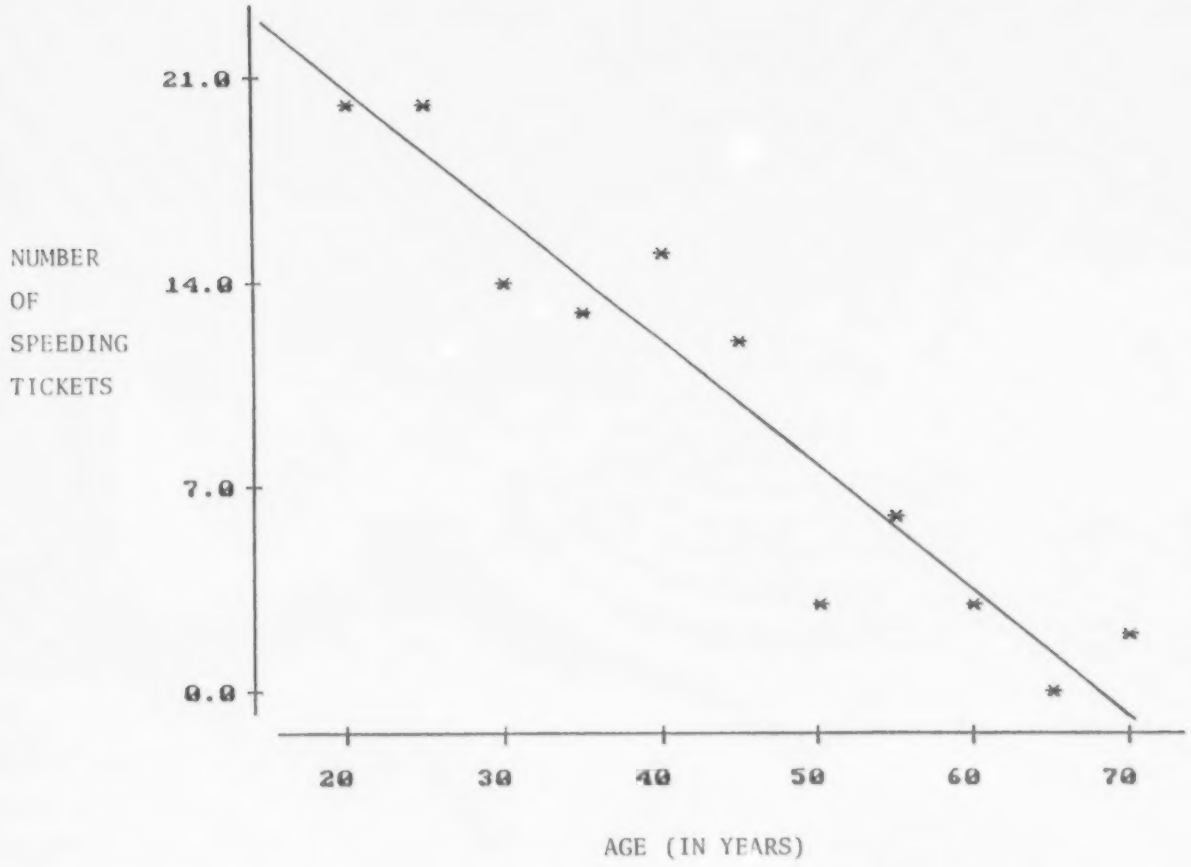
Weekly Allowance and Visits to Cinema Each Year



The graph shows a non-correlation. Weekly allowance is not related to visits to the cinema.

Answer to Exercise 1.3

Age and Number of Speeding Tickets
City of Belleville, May 1989



The graph shows a negative correlation.
As age increases, the number of speeding tickets decreases.

LESSON 2

PRACTICE AND FEEDBACK

Learning Outcomes

1. To be able to organize and interpret correlational data.

2. To be able to distinguish between positive, negative and non-correlations.

Suggested Teaching Strategy

1. Take up the homework. The correct answers are given in the answer section. In providing feedback to students:

(a) Each student should have a prediction for each exercise which says which variables will be involved in the correlation (e.g., for Exercise 1.2: weekly allowance and annual visits to the cinema) and what kind of correlation is expected (e.g., the student might expect a positive correlation).

(b) Check to see that each of the 3 steps in finding a correlation (make a graph, plot the information, and read the graph) has been carried out.

(c) Remind students what a variable is: anything of interest that can change or take a different value.

2. Review the three types of correlations. Table 1.7 (in Lesson 1) gives a summary of the differences. Have students practice distinguishing the three types by completing Exercise 2.1. The correct answers are given in the answer section.

3. Exercises 2.2, 2.3 and 2.4 contain information about Canada's place in the world. Students should select, or be assigned, one exercise in order to

(a) make a prediction, and

(b) use the information in the exercise to test their prediction.

When students have completed the exercise, distribute the appropriate answer sheet. Students should be told that a short quiz will follow the exercise.

4. Assign Quiz #1.

Evaluation

The Answer Section contains a marking scheme for Quiz 1.

Exercise 2.1

What Kind of Correlation is This?

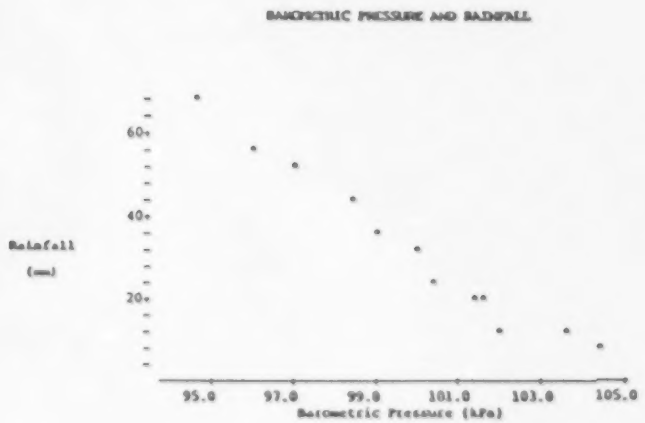
There are two graphs on this page and two more on the next page about factors affecting rainfall.

For each graph:

(a) draw a line or circle on the graph showing the correlation;

(b) state what kind of correlation it is;

(c) state what will happen to the vertical variable when the horizontal variable goes up.



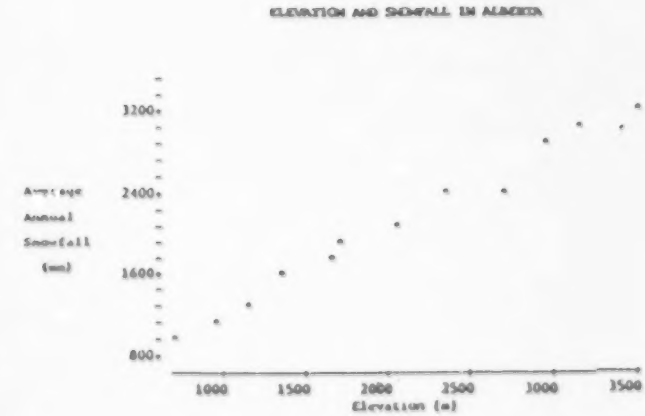
b) _____

c) _____

_____

_____

_____



b) _____

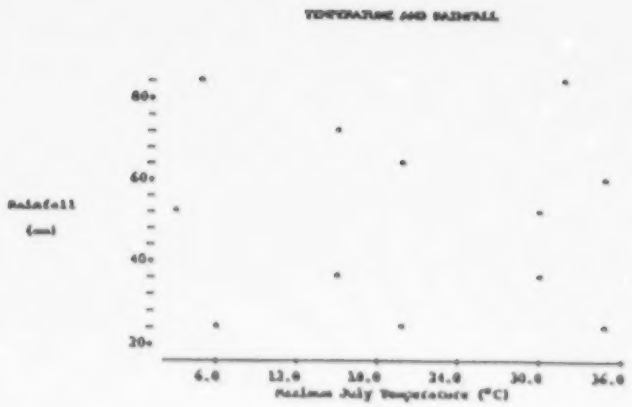
c) _____

_____

_____

_____

Exercise 2.1 continued



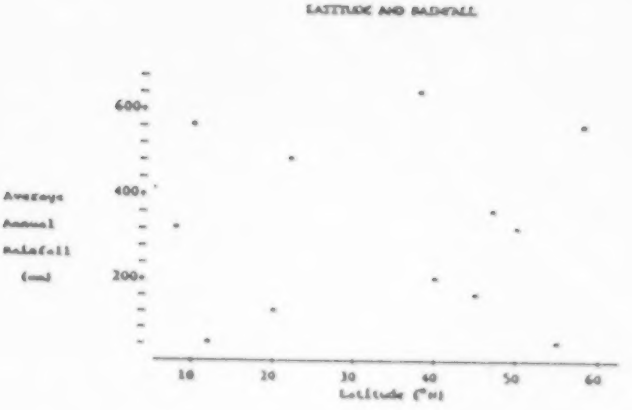
b) _____

c) _____

_____

_____

_____



b) _____

c) _____

_____

_____

_____

Exercise 2.2

Suicides and Movie Attendance

Sean: "Boy am I depressed--I'd better go the movies."

Amanda: "What good would that do?"

Sean: "Well, if it's a happy movie it will cheer me up. If it's a sad movie it will make me feel better, 'cause I'll see people worse off than me. Don't you feel better after going to a movie? I'll bet there'd be fewer suicides if people went to the movies more."

Amanda: "That sounds weird to me."

Is there a relationship between going to the movies and the number of suicides? Use the information in the table to find out.

Number of Suicides and Per Capita Annual Movie Attendance

COUNTRY	NUMBER OF SUICIDES (PER 100,000)	ANNUAL MOVIE ATTENDANCE (PER CAPITA)
USA	12	5.0
Canada	13	3.9
United Kingdom	8	2.5
Australia	11	4.8
Austria	24	3.2
Belgium	15	3.4
Denmark	26	3.9
France	15	3.5
West Germany	20	2.2
Ireland	3	9.0
Italy	5	9.8
Japan	17	1.7
Netherlands	10	2.0
Norway	10	4.5
Spain	4	7.5
Sweden	19	3.1
Switzerland	20	4.2

Exercise 2.3

Saturday Afternoon at the Mall

Read the following story and answer the question below.

> Stephen and Sarah spent Saturday afternoon at the mall trying to find a birthday present for mother. They were in just about every store and the mall was packed with pushing and shoving shoppers. After finally agreeing on a present, they caught the bus for home, totally exhausted and with splitting headaches. They decided that crowds and headaches go together.

Do crowds and headaches go together? Use the information in the table to find out if there is a relationship between population density and headaches.

Percentage of Population Who Suffer from Headaches Regularly and Population Density

COUNTRY	PERCENTAGE OF POPULATION WHO SUFFER HEADACHES REGULARLY	POPULATION DENSITY
USA	13.00	62.3
Canada	17.00	6.7
United Kingdom	42.00	611.4
Australia	38.00	5.0
Austria	36.00	237.7
Belgium	40.00	850.7
Denmark	34.00	312.7
France	39.00	257.4
West Germany	28.00	656.8
Ireland	3.00	121.5
Italy	39.00	491.6
Japan	0.47	803.7
Netherlands	38.00	1065.3
Norway	31.00	34.3
Spain	42.00	189.1
Sweden	27.00	53.2
Switzerland	36.00	431.1

Exercise 2.4

Gun Safety Manual

Read the following newspaper story and answer the question below.

> The Solicitor-General today announced a major program which will lead to a dramatic reduction in the number of deaths caused by firearms in Canada. The program follows a series of hunting and gun cleaning accidents that have aroused concern across the country. The key element in the government program is an instructional manual which describes how to store, maintain and use firearms. The manual will be distributed free to hunters and collectors where ever ammunition is sold.
>
> Nick Walners, an opposition spokesperson, was extremely critical of the program, calling it too little, too late. He called the program a cynical charade: "The government knows that the people who need this information don't read books. Nothing less than a video will do.

Is there a relationship between reading and firearms? Use the information in the table to find out if the percentage of the population who never read books is related to the number of deaths caused by firearms.

Number of Firearm Deaths and the Percent of the Population in a Given Year Who Never Read Books

COUNTRY	PERCENT OF POPULATION WHO NEVER READ BOOKS	NUMBER OF FIREARM DEATHS
USA	74	130
Canada	45	73
United Kingdom	29	7
Australia	48	53
Austria	33	11
Belgium	45	20
Denmark	25	2
France	38	23
West Germany	34	7
Ireland	40	31
Italy	68	24
Japan	22	4
Netherlands	27	5
Norway	30	30
Spain	52	24
Sweden	28	10
Switzerland	19	13

Quiz 1

Casting a Light on Crime or Catching Criminals?

The Mayberry City Council had a problem: crime in mall parking lots. Alderman Jones said, *"We need more patrols. Let's hire an extra police officer. Crime will go down when the criminals know they are more likely to be caught."* But Alderman Walton had a different idea. *"Let's install more lights in the malls. Crime will go down when the criminals know they can be seen."*

a. Who was right? Use the information in the table to find out if the mall lighting and crime are related.

b. What kind of correlation is this?

c. What will happen to the number of crimes if the number of lights goes up?

CRIME IN MAYBERRY MALL PARKING LOTS

MALL	NUMBER OF CRIMES/YEAR	NUMBER OF LIGHTS
Westwind Place	19	120
Fairmount Shopping Centre	40	40
Lakeside Centre	2	200
Ridgeview Plaza	12	145
Town Square	26	100
Bayview Mall	48	20
Auburn Lanes	5	180
Pinecrest Mall	32	65

LESSON 2

ANSWER SECTION

Answer to Exercise 2.1

Barometer: There should be a straight line running from top left to bottom right. This is a **negative** correlation. When the barometer goes up, rainfall goes down.

Elevation: There should be a straight line running from bottom left to upper right. This is a **positive** correlation. When the elevation in Alberta goes up, the annual snowfall goes up.

Temperature: There should be a circle around the cases. This is a **non-correlation**. When temperature goes up, there is no consistent pattern in rainfall.

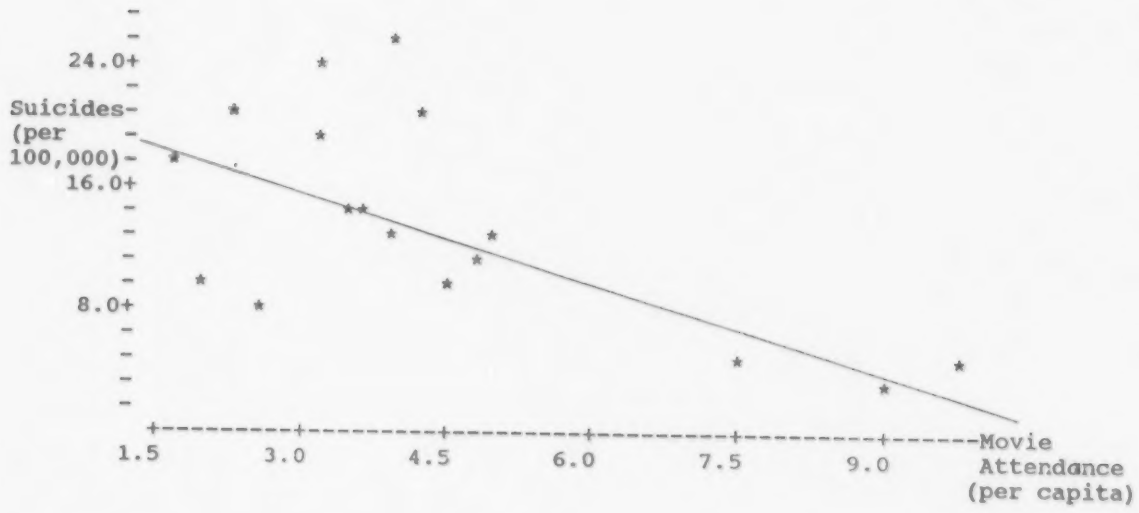
Latitude: There should be a circle around the cases. This is a **non-correlation**. When latitude goes up, there is no consistent pattern in rainfall.

Answer to Exercise 2.2

Suicides and Movie Attendance

There is a negative correlation. For this sample of countries, as movie attendance increases, the number of suicides decreases.

Number of Suicides and Per Capita Annual Movie Attendance

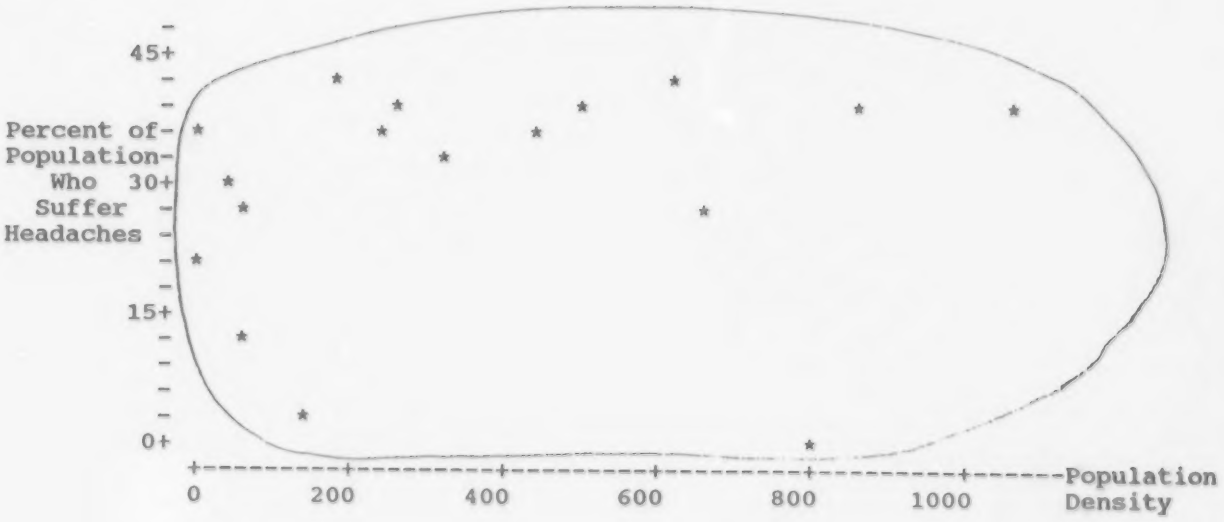


Answer to Exercise 2.3

Saturday Afternoon in the Mall

There is a non-correlation. For this sample of countries, there is no relationship between population density and percentage of people who suffer from headaches regularly.

Percentage of Population Who Suffer from Headaches Regularly and Population Density

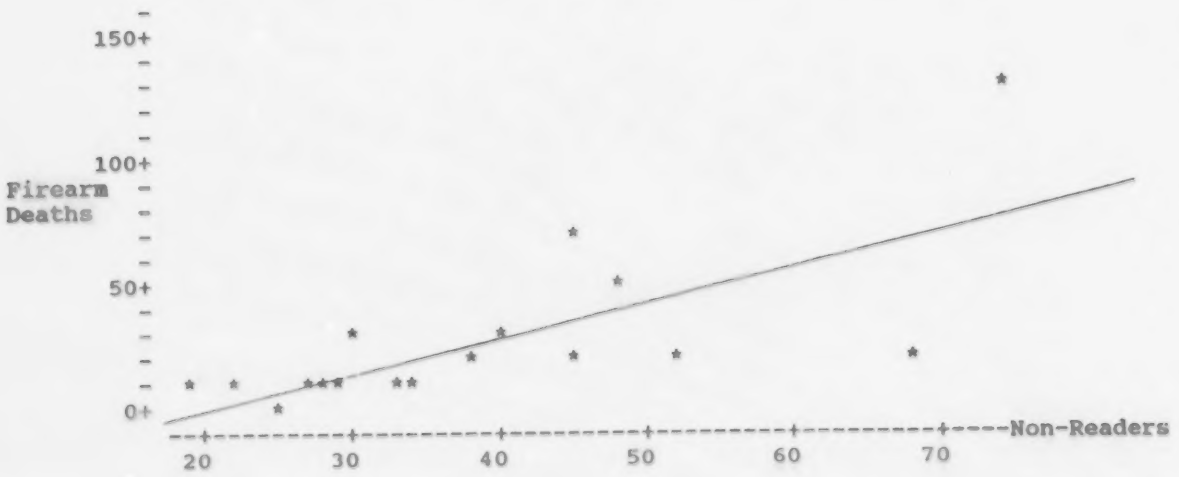


Answer to Exercise 2.4

Gun Safety

There is a positive correlation. For this sample of countries, as the percentage of the population who never read books increases, the number of deaths caused by firearms increases.

Number of Firearm Deaths and the Percentage of the Population in a Given Year Who Never Read Books



MARKING QUIZ 1

Make a Graph - 10 marks

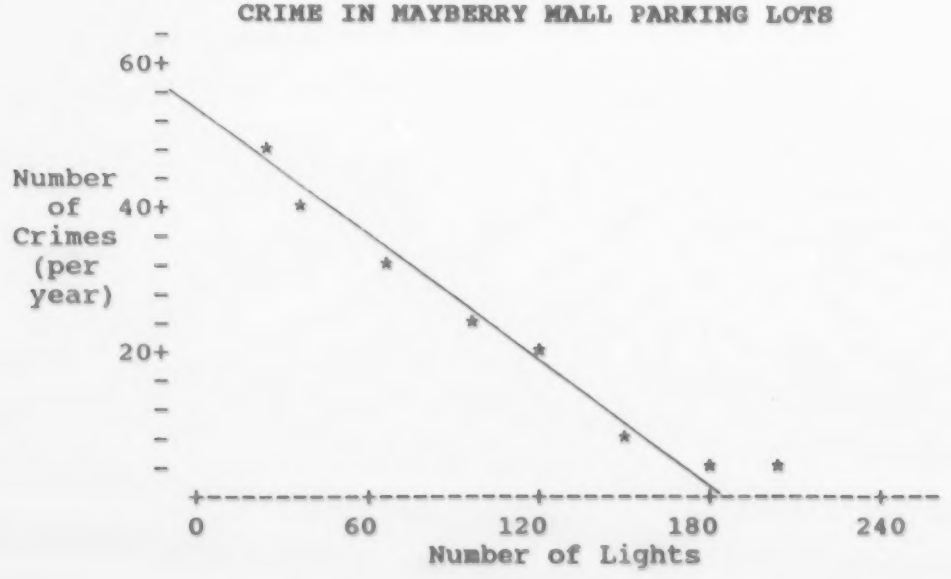
- names each axis "number of crimes" — 2 marks
  - * and "number of lights"
- puts in horizontal scale — 3 marks
  - * from lowest score (1 mark)
  - * to highest score (1 mark)
  - * in equal units (1 mark)
- puts in vertical scale — 3 marks
- labels graph "Crime & Lighting in Mayberry" — 2 marks

Put Information in the Graph - 5 marks

- puts all data in graph correctly — 5 marks
  - * 3 marks if one error
  - * 1 mark if two errors

Read the Graph - 5 marks

- draws a line through the cases — 2 marks
- states it is a negative correlation — 1 mark
- concludes "when lighting goes up, crime goes down" — 2 marks



LESSON 3

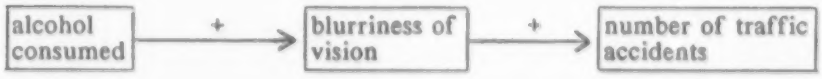
LENGTH OF GROWING SEASON

Learning Outcomes

1. To be able to solve a connected series of correlational problems.
2. To construct a simple model of crop production.

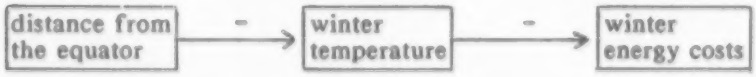
Suggested Teaching Strategy

1. Correlational problems often come in a connected series called a model. For example, a simple model for traffic accidents might look like this:



The model shows two correlations. The arrow between box 1 and box 2 shows that the amount of alcohol consumed is related to blurred vision; the plus sign shows that the correlation is positive: more liquor means blurrier vision. The arrow from box 2 to box 3 shows that blurriness of vision is related to number of traffic accidents; the plus sign shows that it is a positive correlation: blurrier vision means more accidents.

A geographic model is also a series of connected correlations. Provide an example of a geographic model and invite students to suggest additional examples. For example:



2. **Present the following situation to students.**

> ***A committee from the Ministry of Agriculture was looking at the farm situation in Ontario. It did not look good. Farm prices were down; interest costs were up. The committee decided that things might improve if they could get more farmers to grow soya beans. But which farmers should be encouraged to change? Some committee members thought that areas of the province that get lots of rainfall should switch. Others thought the length of the growing season was more important.***

Optional: Review the concept of cartographic correlation using choropleth maps. Have the students produce three choropleth maps for Ontario using the data in Table 3.1: one should show precipitation; another should show degree days, and the third should show soya bean production. Use the map to find out which variable influences soya bean production. Upon completion of this and subsequent activities, students should compare cartographic correlation with statistical correlation. Each method has its strengths and weaknesses. For example, cartographic correlation has the advantage of providing a "sense of place" that is not visible in a graph. But the relationships between the variables are much harder to see and it takes a great deal of time to produce the choropleth maps.

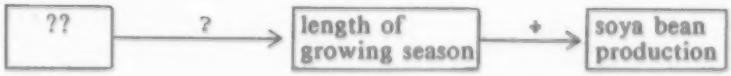
> [**TEACHER NOTE**: Cartographic correlation is finding a relationship between two or more variables using areal density maps. A choropleth map is a thematic map which displays areal density by tonal shadings.]

Have students use the maps to help the committee decide.

Provide students with the data in Table 3.1 (*Agriculture Statistics for Ontario Counties*). Have students find out which variable (precipitation or length of growing season) affects soya bean production. Review the concept of degree days as a measure of length of growing season, if it is not familiar to students.

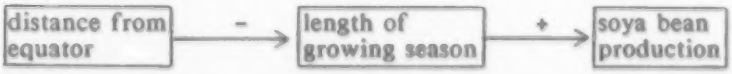
> [**TEACHER NOTE**: Degree days are calculated from a daily temperature average base of 5 degrees C, the temperature when plant growth begins. Each degree above 5 is one degree day. A spring day with an average temperature of 13 degrees C equals 8 degree days.]

3. Take up the results of the investigation. The correct answers are shown in Figures 3.1 and 3.2: soya bean production is positively related to length of growing season and is unrelated to precipitation. The first part of a model of crop production looks like this:



Invite students to speculate about the variables that might affect the length of the growing season. Provide students with the data in Table 3.4 (*Canadian Climate Statistics*). Have students find out which variable (elevation or latitude) affects the length of the growing season.

4. Take up the results of the investigation. The correct answers are in Figures 3.3 and 3.4: degree days are negatively related to latitude and unrelated to elevation. The completed model looks like this. Invite students to speculate on other variables that might affect it.



5. **Optional**: Use the information in Optional Exercise 3.1 to find out if the agricultural production model also works with a second crop, wheat.

Evaluation

Feedback to students should focus on the steps in finding a correlation: make a graph; put information in the graph; read the graph.

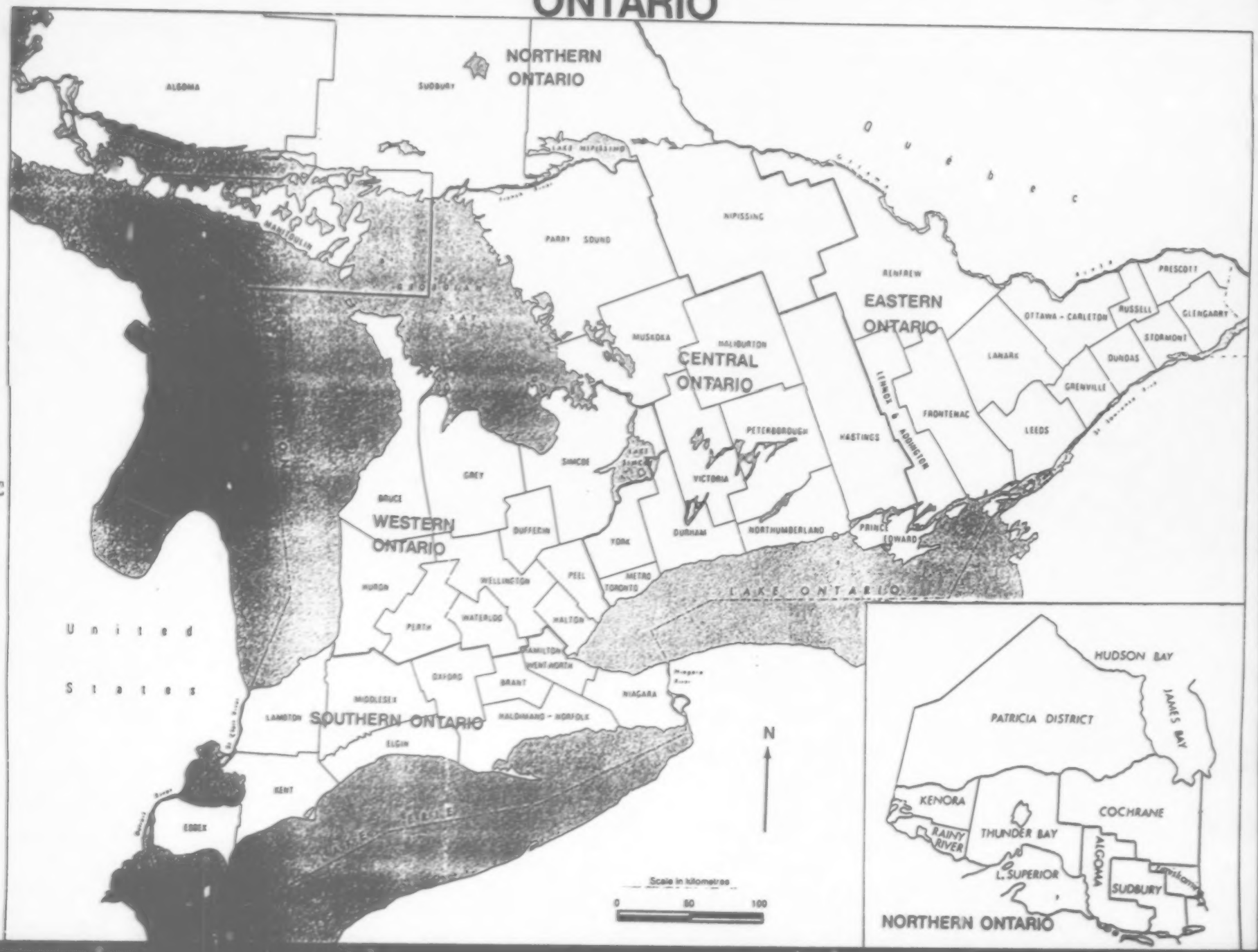

ONTARIO
NORTHERN ONTARIO
ALGOMA
SUDBURY
LAKE NIPISSING
NIPISSING
PARRY SOUND
MANITOULIN
GEORGIAN BAY
MUSKOKA
HALIBURTON
CENTRAL ONTARIO
RENFREW
EASTERN ONTARIO
PRESCOTT
OTTAWA - CARLETON
RUSSELL
GLENGARRY
STORMONT
DUNDAS
LANARK
GRENVILLE
LENNOX & ADDINGTON
FRONTENAC
LEEDS
HASTINGS
PETERBOROUGH
VICTORIA
SIMCOE
GREY
BRUCE
WESTERN ONTARIO
DUFFERIN
YORK
DURHAM
NORTHUMBERLAND
PRINCE EDWARD
PEEL
METRO TORONTO
HURON
WELLINGTON
PERTH
WATERLOO
HALTON
HAMILTON
WENTWORTH
OXFORD
BRANT
NIAGARA
MIDDLESEX
LAMBTON
SOUTHERN ONTARIO
HALDIMAND - NORFOLK
ELGIN
KENT
ESSEX
LAKE ONTARIO
LAKE ERIE
United States
Quebec
N
Scale in kilometres
0
80
100
HUDSON BAY
JAMES BAY
PATRICIA DISTRICT
KENORA
RAINY RIVER
THUNDER BAY
COCHRANE
ALGOMA
L. SUPERIOR
SUDBURY
NORTHERN ONTARIO

Table 3.1

Agriculture Statistics for Ontario Counties

COUNTY	SOYA BEANS (kg/hectare)	AVERAGE ANNUAL PRECIPITATION (mm)	DEGREE DAYS ABOVE 5°C
Essex	2689	848.8	2533.3
Kent	2891	807.5	2532.4
Lambton	2353	890.2	2230.0
Oxford	2154	861.6	2117.3
Elgin	2286	912.0	2187.0
Haldimand-Norfolk	2017	888.2	2185.9
Dufferin	1546	788.5	1796.2
Grey	1950	1024.2	1990.1
Huron	2219	925.7	2056.8
Hastings	2154	855.2	2216.6
Peterborough	2219	793.0	2012.9
Prince Edward	2219	946.9	2224.3
York	2017	780.8	2040.3
Dundas	1950	927.9	2171.2
Frontenac	1681	867.3	2014.4
Renfrew	1815	770.3	2028.4

Figure 3.1

Soya Beans and Degree Days Above 5°C for Sixteen Counties in Ontario

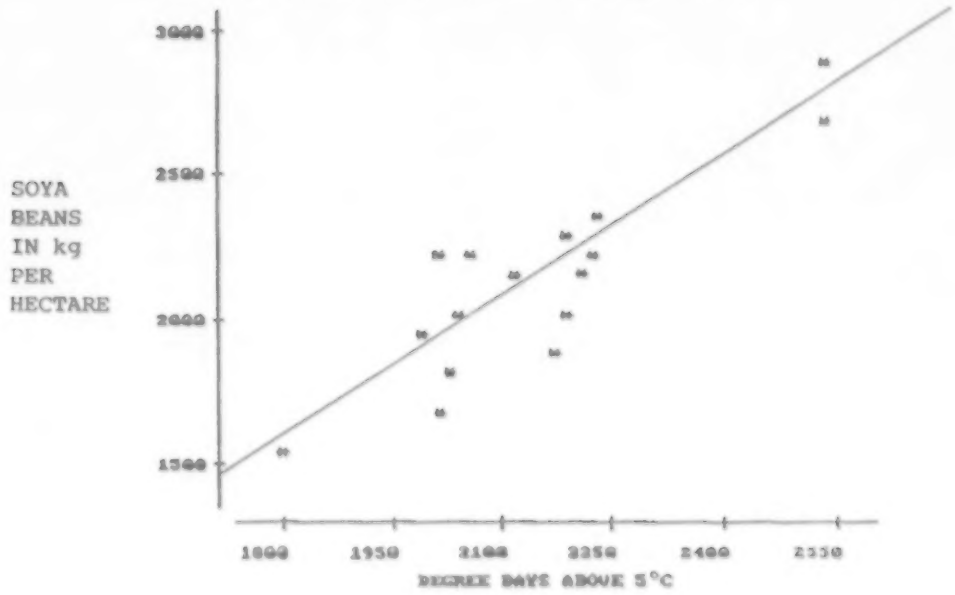
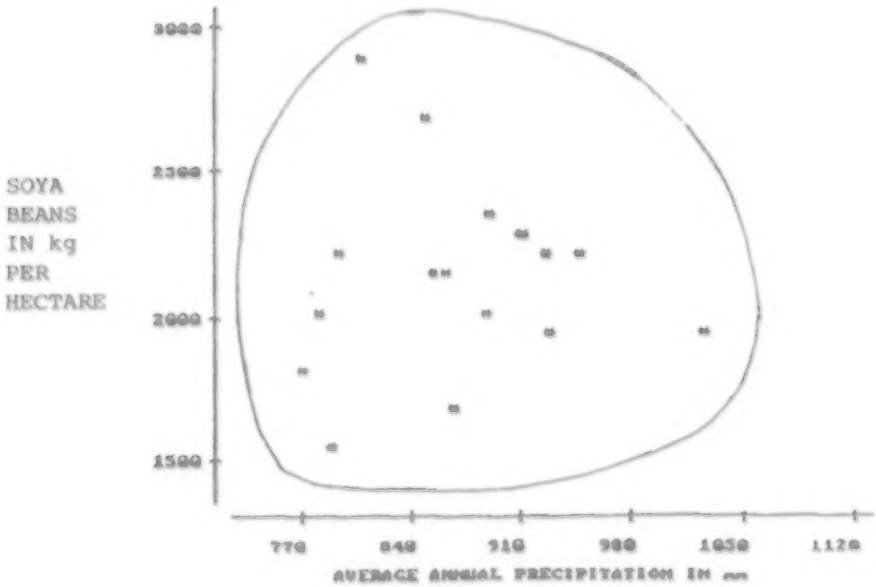


Figure 3.2

Soya Beans and Average Annual Precipitation for Sixteen Counties in Ontario



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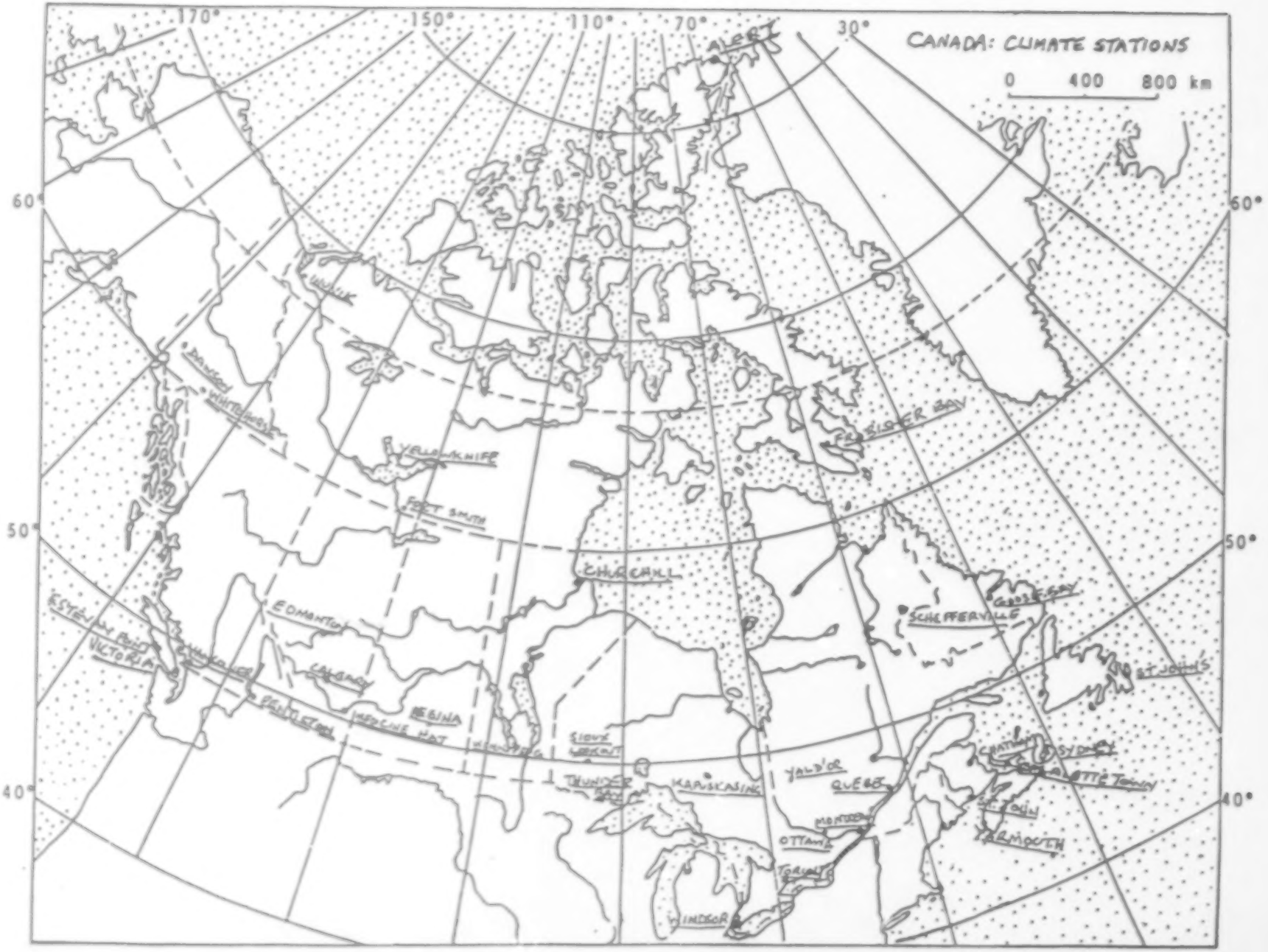

CANADA: CLIMATE STATIONS
0 400 800 km
170°
150°
110°
70°
30°
60°
50°
40°
ALERT
INUVIK
WHITEHORSE
YELLOWKNIFE
FORT SMITH
CHURCHILL
EDMONTON
CALGARY
REGINA
MEDICINE HAT
THUNDER BAY
KAPUSKASING
YARMOUTH

Table 3.2

Climate Statistics in Canada

CITY	LATITUDE (°N)	ELEVATION (m)	DEGREE DAYS ABOVE 5°C
St. John's	48	141	1224
Goose Bay	53	44	1022
Charlottetown	46	57	1724
Montreal	46	57	2113
Toronto	44	116	2127
Windsor	42	194	2533
Calgary	51	1079	1387
Edmonton	54	676	1328
Penticton	49	342	2136
Estevan Point	49	006	1607
Dawson	64	324	1015
Whitehorse	61	698	897
Fort Smith	60	203	1130
Yellowknife	62	208	1027
Inuvik	68	61	665
Frobisher Bay	63	21	179

Figure 3.3

Latitude and Degree Days Above 5°C For Sixteen Locations Across Canada

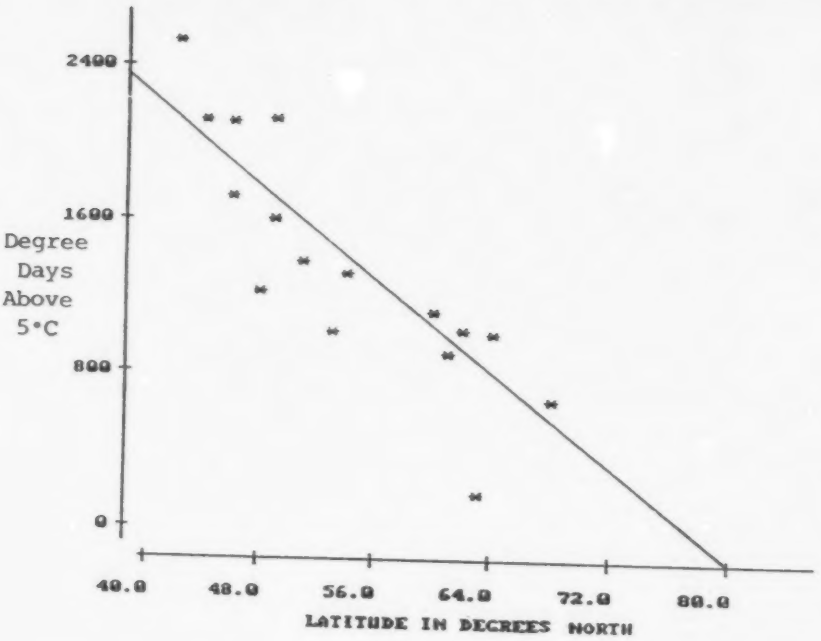
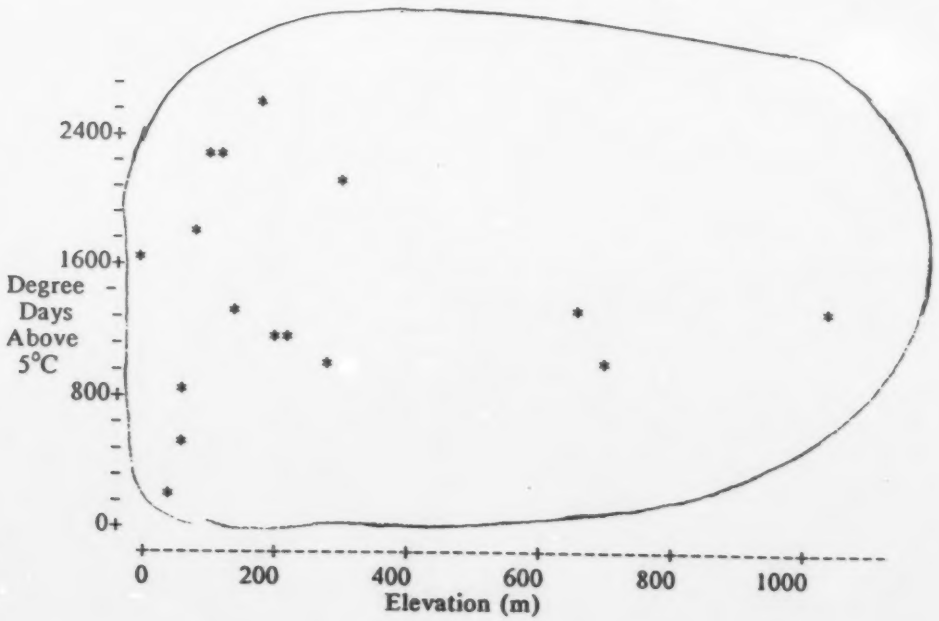


Figure 3.4

Elevation and Degree Days



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Optional Exercise 3.1

Where does Wheat Grow?

Emily and Scott decided to eat lunch together in the cafeteria so they could practice their presentation for geography class. Their friend, Allison, came along and joined them.

"Hey, what are you guys up to?" *"We're just rehearsing our geography presentation,"* replied Scott. *"What topic are you doing?"* asked Allison. *"Wheat production in Saskatchewan,"* replied Emily. *"Oh, wow,"* said Allison, *"that's neat, I'm doing mine on wheat production in Ontario."* *"Oh, ya, like we're supposed to believe that,"* said Scott, *"since when did Ontario start producing wheat?"*

Emily and Scott both laughed and went back to work on their presentation.

"No, guys, I'm serious. That really is my topic. Everyone thinks that only the western provinces produce wheat, but we really do produce wheat here in Ontario. I have a table right here in my binder to prove it."

"Where in Ontario do they produce wheat?" asked Emily, a little sheepishly.

"In lots of counties," as she pointed to her table, *"see it depends on the amount of average annual precipitation and the number of degree days above 5 C."*

Using the information in the table below, find out which variable affects winter wheat production in Ontario--precipitation or length of growing season.

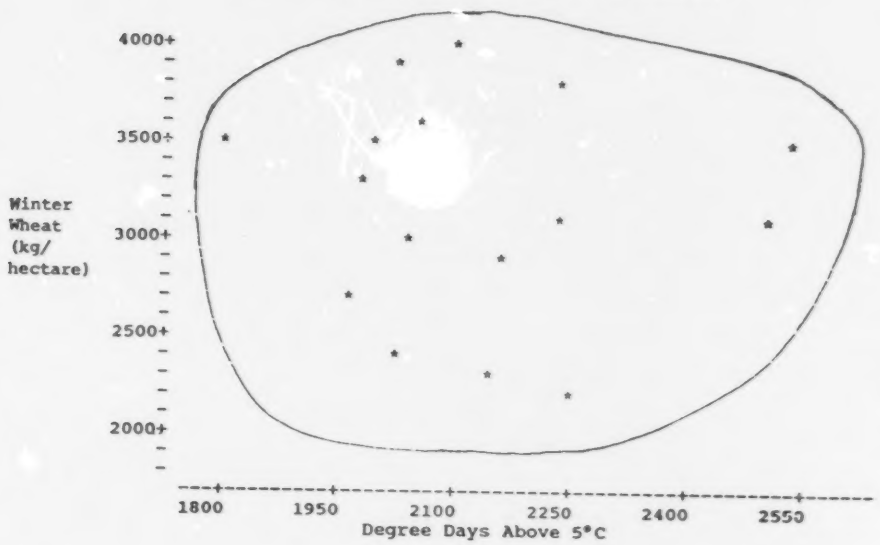
County	Winter Wheat (kg/hectore)	Avg. Annual Precip. (mm)	Deg. Days Above 5 C
Essex	3294	848.8	2533.3
Kent	3698	807.5	2532.4
Lambton	3832	890.2	2230.0
Oxford	3967	861.6	2117.3
Elgin	3496	912.0	2187.0
Haldimand-Norfolk	2891	888.2	2185.9
Dufferin	3496	788.5	1796.2
Grey	2756	1024.2	1990.1
Huron	3278	925.7	2056.8
Hastings	3227	855.2	2216.6
Peterborough	3945	793.0	2012.9
Prince Edward	2250	946.9	2224.3
York	3496	780.8	2040.3
Dundas	2387	927.9	2171.2
Front	2488	867.3	2014.4
Renfrew	3160	770.3	2028.4

Answer To

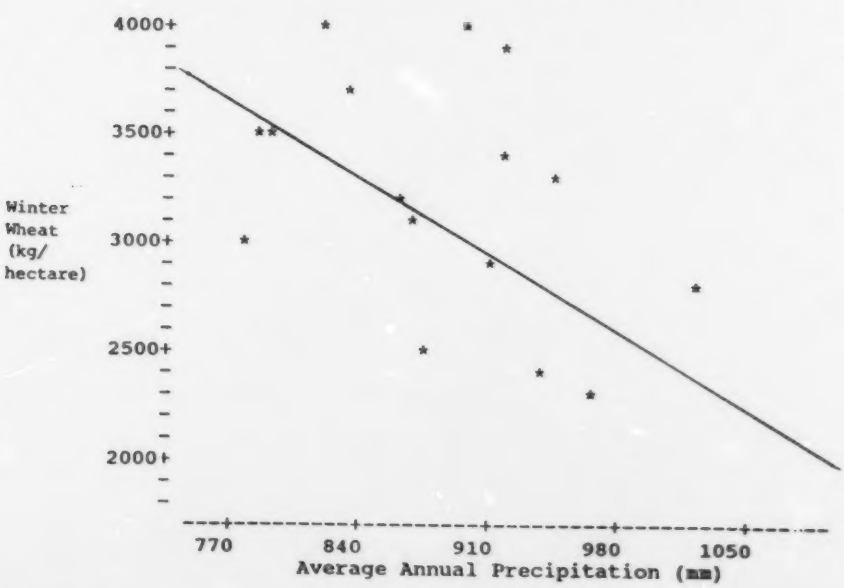
Optional Exercise 3.1

There is a non-correlation in the first graph. There is no relationship between degree days and winter wheat production. There is a negative correlation in the second graph. As the average annual precipitation increases, the production of winter wheat decreases.

Winter Wheat and Degree Days Above 5°C for Sixteen Counties in Ontario



Winter Wheat and Average Precipitation for Sixteen Counties in Ontario



Lesson 4

Controlling Variables

Learning Outcomes

1. To be able to control variables when organizing and interpreting correlational data.

Suggested Teaching Strategy

1. Most grade 9 students know that it gets colder as elevation increases. Tables 4.1 to 4.3 contain data on temperature, latitude and elevation in three continents. Have students find the relationship between elevation and temperature for each set of data. [Teachers may wish to have each student do all three sets or divide up the task so each student does only one.] If there has been a significant time lapse since the completion of Lesson 3, teachers might wish to review the three steps in finding a correlation, and the three types of correlations, introduced in Lesson 1.

2. Display the results. Figure 4.1 (Eurasia) shows that there is a negative correlation between elevation and temperature (the higher you get, the colder it is); Figure 4.2 (North America) shows there is a non correlation (height has nothing to with temperature); Figure 4.3 (South America) shows there is a positive correlation (the higher you get, the warmer it is).

Invite students to explain why such different results were found. Direct students' attention to the latitude information in the tables; remind them that latitude makes a difference to temperature. The world map shows the location of each set of weather stations.

.In Table 4.1 (Eurasia) all the places are within the same band of latitude. The comparison of different elevations is a fair one because latitude is kept more or less the same for all the places.

.In Table 4.2 (North America) latitude is not kept the same; some of the high elevation places are near the equator and some of the low elevation places are distant from the equator. This distorts the results. There is a relationship between elevation and temperature but we can't see it because the relationship between latitude and temperature is in the way. Table 4.4 and Figure 4.4 show what happens when North American weather stations are selected within the same band of latitude; the correct negative correlation between elevation and temperature is visible.

.In Table 4.3 (South America) the effect of latitude is even more extreme. All the high elevation places happen to be near the equator and all of the low elevation places happen to be distant from the equator. The relationship between latitude and temperature is so strong that it completely overturns the relationship between elevation and temperature. Table 4.5 and Figure 4.5 show what happens when South American weather stations are selected within the same band of latitude: the correct negative correlation between elevation and temperature is visible.

3. Provide a real life example to consolidate the concept of controlling variables. For example, present the following situation.

> *The Society for the Prevention of Botulism was investigating the quality of cooking in secondary school cafeterias. Complaints had been received from students about the amount of time being taken to prepare the food. The students were convinced that if the kitchen staff took more time, the food would taste better. Researchers from the Society collected information on food preparation time and student ratings of the meals each day for 6 weeks. The results are shown in Figure 4.6.*

Figure 4.6 shows a non-correlation. Ask students to think of variables other than amount of preparation time that might affect student ratings of meal quality. For example, *quality and freshness of the food, how popular the menu is, etc.* Return to the story.

> *When the results showed a non-correlation, some of the students began to think about the different cooks who had been working in the cafeteria in the past six weeks. Some of these cooks were trained in food preparation; others were not. The students asked the Society researchers to analyze the data separately, CONTROLLING FOR cook training. The results are shown in Figure 4.7 and 4.8.*

Figures 4.7 and 4.8 show very different results. Each graph shows there is a relationship between cooking time and student ratings of the quality of the meal. But one graph shows a positive correlation; the other shows a negative correlation. When trained cooks spend more time preparing the meal, student ratings increase. But when untrained cooks spend more time preparing the meal, the opposite occurs: student ratings decline. Ask students why this might be the case. For example, *the trained cooks know how to use their time and/or when untrained cooks spend more time it is because they are attempting complicated meals for which they do not have the skills.*

Controlling variables means **revealing the influence of a hidden variable.** In the cafeteria example the relationship between preparation time and food ratings was not visible when the data from trained and untrained cooks were lumped together. When the data were separated it was discovered that the relationship between preparation time and food ratings was positive for one group of cooks and negative for another group of cooks.

> [TEACHER NOTE: Many students think that you can make statistics say whatever you want. It is important for them to realize that this is not the case if you control variables that might affect the result.]

4. Provide practice in identifying hidden variables. Distribute copies of newspaper clippings reporting correlational findings. [The introduction of this package contains many examples.] Have students identify the hidden variable(s) that might be affecting the findings. AND/OR, assign Exercise 4.1. In Exercise 4.1 students must identify the uncontrolled variable that is creating a misleading result. Have students identify additional examples.

> [**Teacher Note**: Students should recognize that you only control for variables that are expected to make a difference to the result.]

5. Assign Exercise 4.2. Students should observe that the control variable [driver sex] makes a difference. The relationship between age and speeding is different for males and females.

6. OPTIONAL: Optional Exercise 4.3 contains an additional practice in controlling variables, in this case for baseball statistics.

Evaluation

Answers to student exercises are given in the answers section. Feedback should focus on the need to control variables. Some common errors made by students include:

- ignoring the control variable;
- focusing on the wrong relationship, e.g., students might produce a graph comparing the total number of speeding tickets of males and females, controlling for age--this error results in the relationship of greatest interest (age and speeding) being hidden from view.

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WORLD: CLIMATE STATIONS

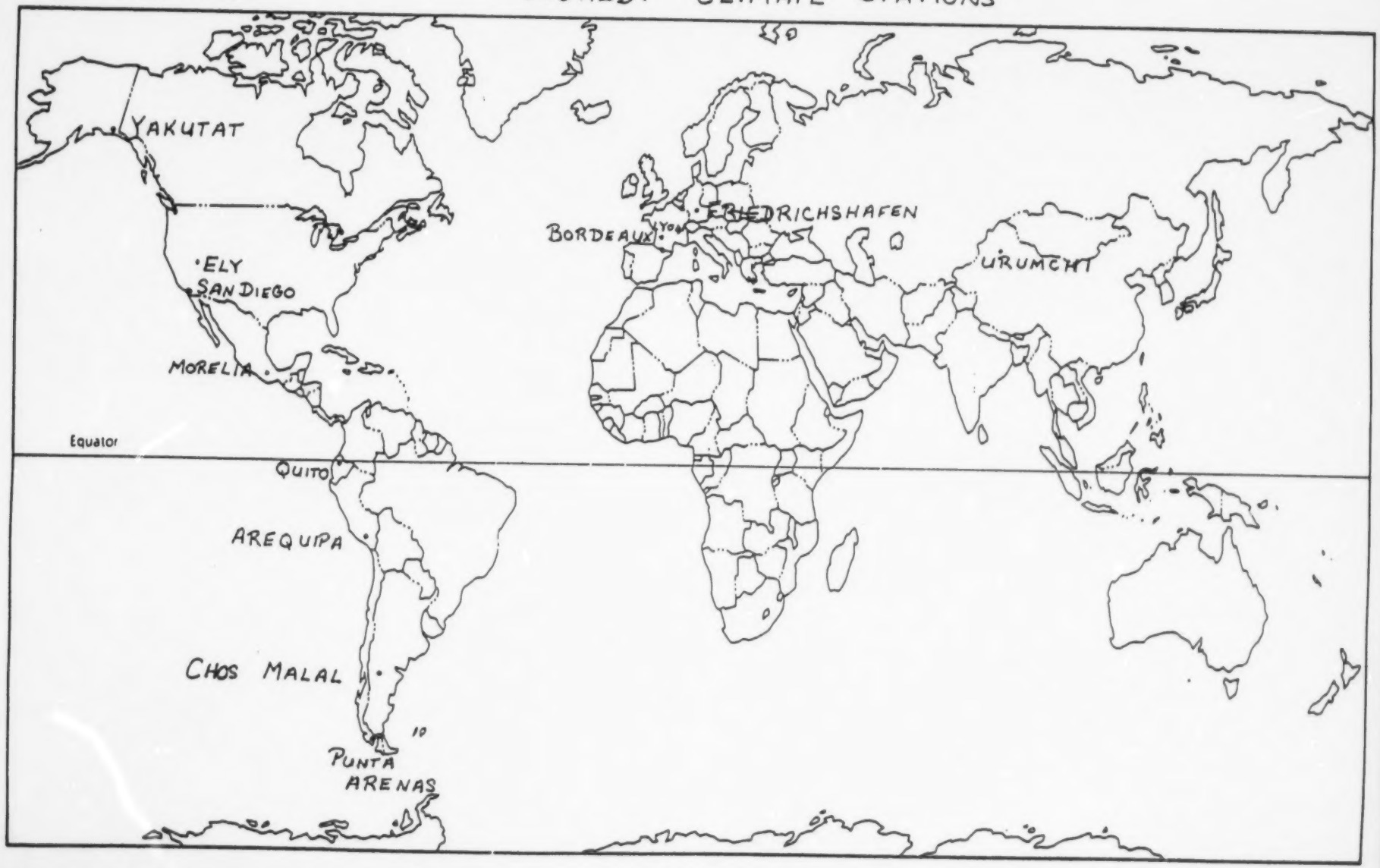

TABLE 4.1

LATITUDE, ELEVATION AND TEMPERATURE IN EURASIA

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (°N)
Bordeaux, France	20	12	44
Lyon, France	21	11	45
Friedrichshafen, Germany	407	9	47
Urumchi, China	913	5	43

TABLE 4.2

LATITUDE, ELEVATION AND TEMPERATURE IN NORTH AMERICA

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (°N)
Ely, Nevada	1909	7	39
San Diego, Ca.	0009	17	33
Morelia, Mexico	1923	18	20
Yakutat, Alaska	0009	4	60

TABLE 4.3

LATITUDE, ELEVATION AND TEMPERATURE IN SOUTH AMERICA

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (°S)
Quito, Ecuador	2812	13	0
Arequipa, Peru	2332	12	16
Chos Malal, Argentina	858	10	37
Punta Arenas, Chile	33	7	53

FIGURE 4.1

LATITUDE, ELEVATION AND TEMPERATURE IN EURASIA

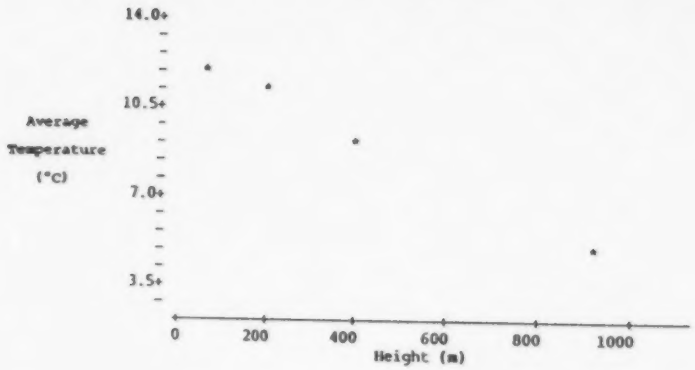

FIGURE 4.2

LATITUDE, ELEVATION AND TEMPERATURE IN NORTH AMERICA

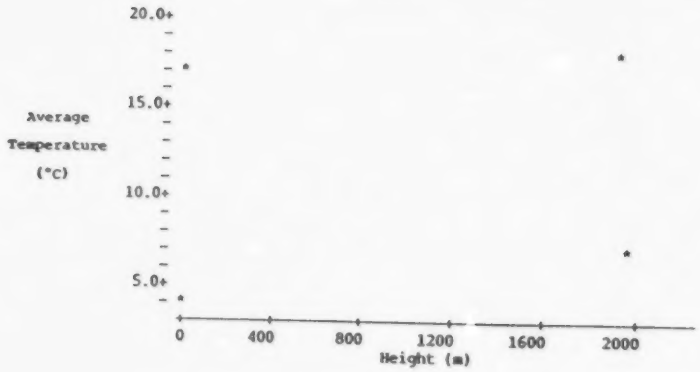

FIGURE 4.3

LATITUDE, ELEVATION AND TEMPERATURE IN SOUTH AMERICA

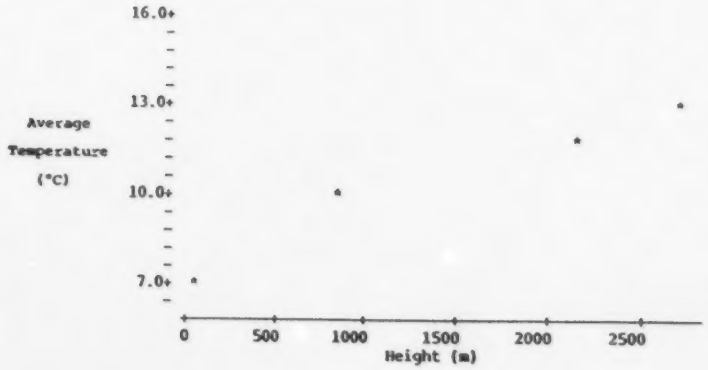

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Table 4.4

Latitude, Elevation And Temperature In North America

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (°N)
Ely, Nevada	1909	7	39
San Diego, Ca.	0009	17	33
Asheville, North Carolina	0687	14	34
Grand Junction, Colorado	1475	11	39

Figure 4.4

Latitude, Elevation And Temperature In North America

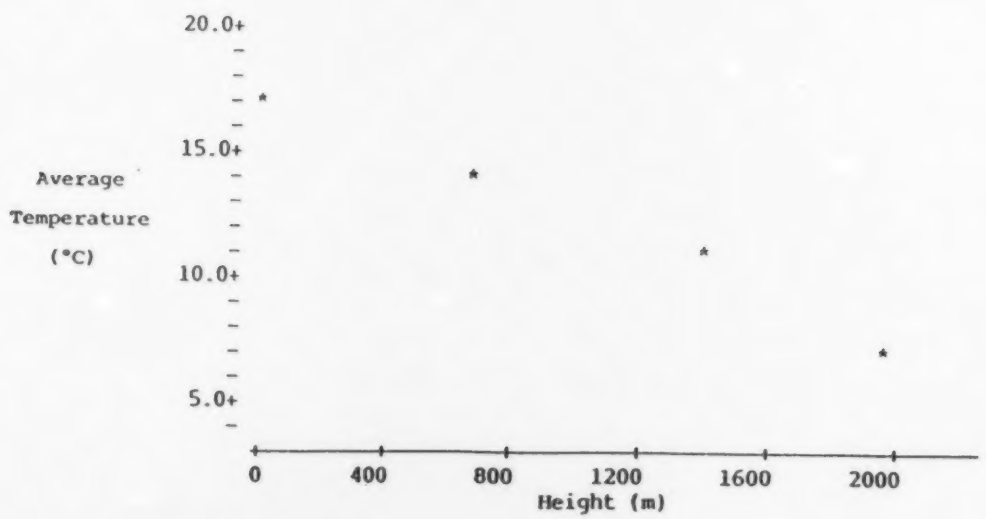

Table 4.5

Latitude, Elevation And Temperature In South America

PLACE NAME	ELEVATION (m)	AVERAGE TEMPERATURE (°C)	LATITUDE (°S)
Valparaiso, Chile	0041	14	33
Cochabamba, Bolivia	1850	6	17
Chos Malal, Argentina	858	10	37
Salta, Argentina	1182	9	25

Figure 4.5

Latitude, Elevation And Temperature In South America

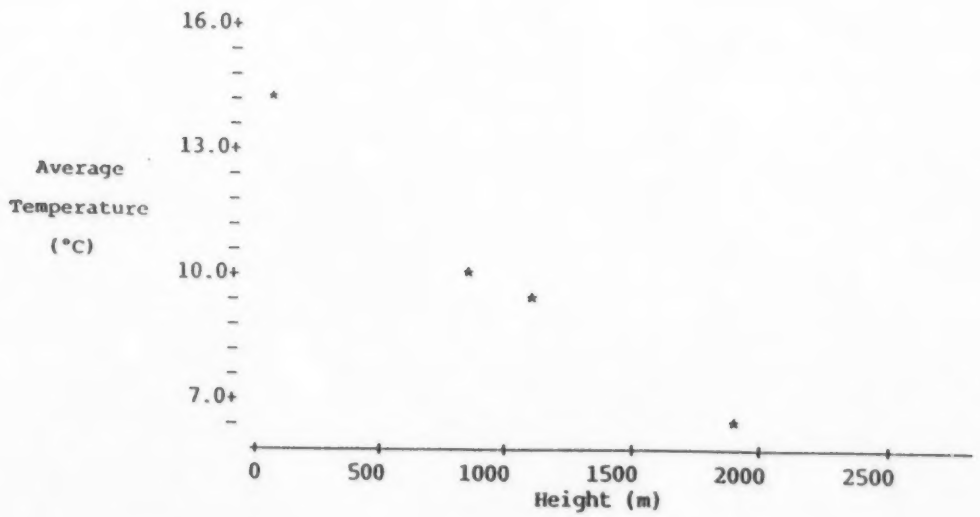

Figure 4.6

Preparation Time and Meal Ratings

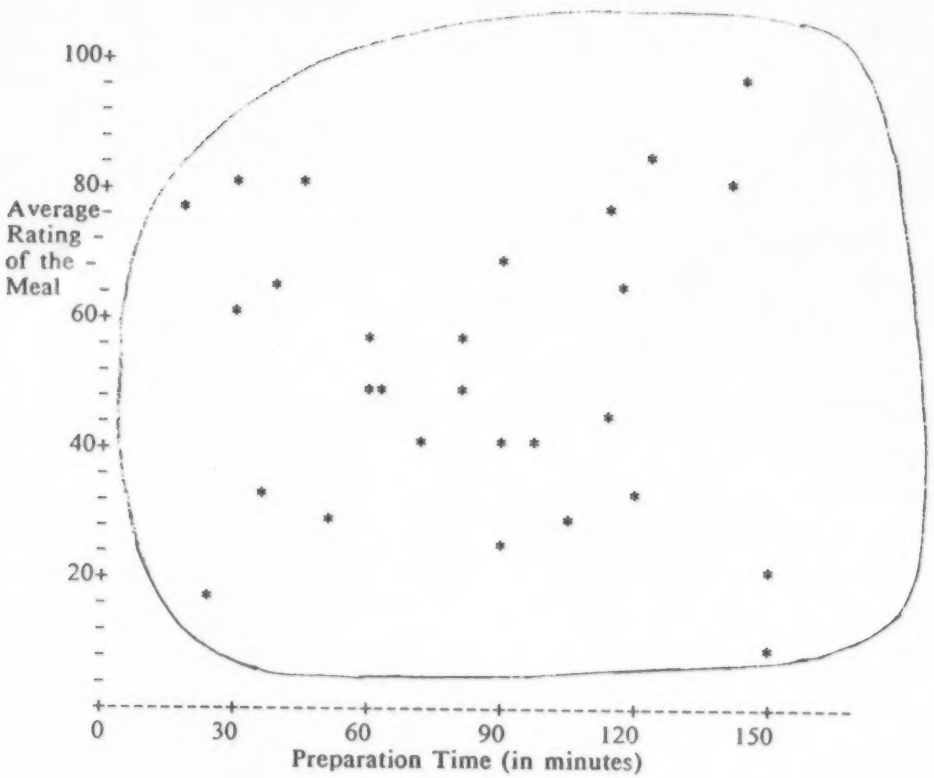

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Figure 4.7

Preparation Time and Meal Ratings For Trained Cooks

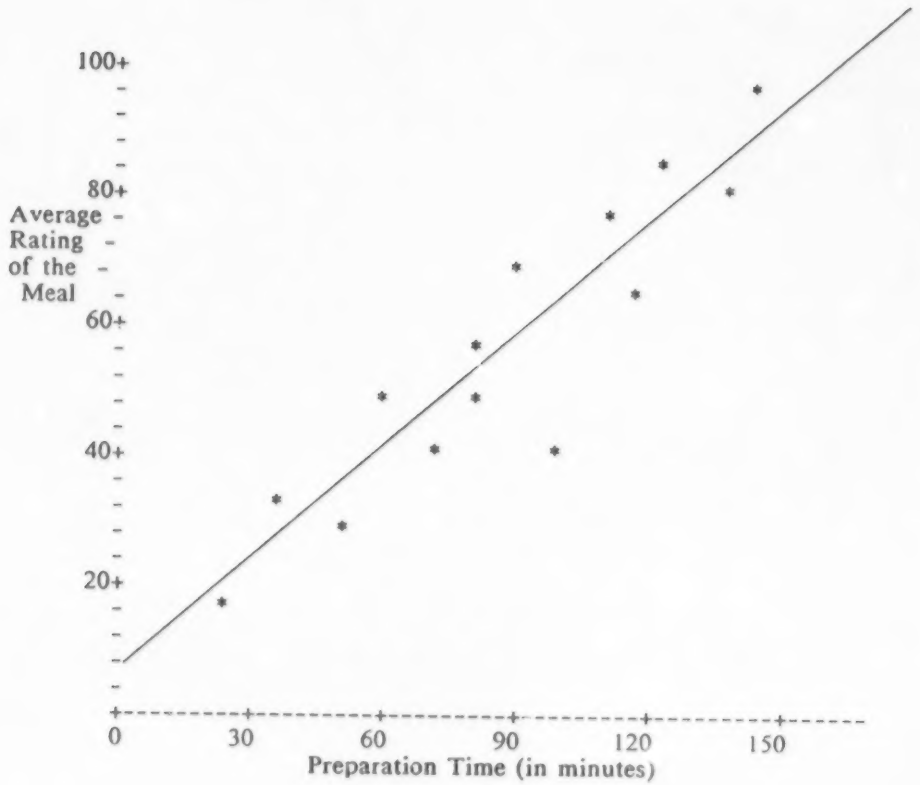

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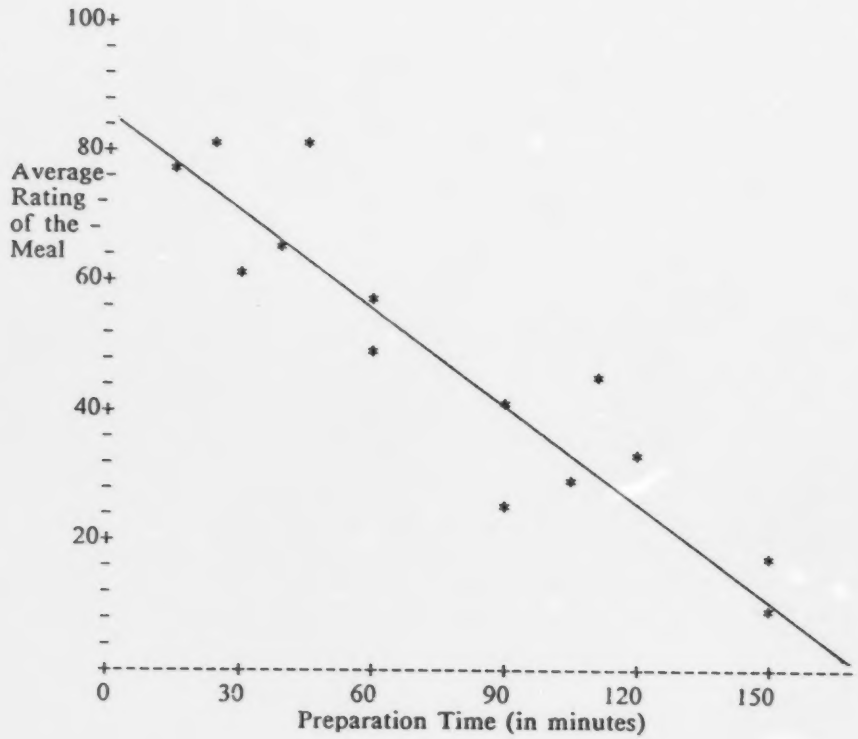
Figure 4.8

Preparation Time and Meal Ratings For Untrained Cooks



Exercise 4.1

What is the Hidden Variable?

Each of the following situations contains a misleading result. For each situation, identify the variables involved in the correlation and the missing control variable which accounts for the misleading finding. Make sure that the control variable(s) you identify is something that is likely to make a difference to the relationship of interest.

1. A study found that weight lifters with less than six months experience, were able to lift more weight than weight lifters with more than six months experience. Should we conclude that there is a negative correlation between experience and amount of weight lifted?

2. A medium size pizza at Lorenzo's costs less than a small pizza at Zeppi's. Should we conclude that there is a negative correlation between pizza size and pizza price?

3. Sarah has a small dog that rushes to the food bowl at supper and gobbles it down in a flash. Heather has a large dog that picks at the food in the bowl. Should we conclude there is a negative correlation between size of the dog and speed of eating dog food?

4. Mrs. Jones has two bushes in front of her driveway. The one that is in the shade is growing very quickly. The other bush in the sunlight is growing very slowly. Should we conclude there is a negative relationship between growth of bushes and amount of sunlight?

5. Fred got a much higher score on *Super Mario Brothers* than his sister. Should we conclude that boys are better at Nintendo games than girls?

Exercise 4.2

Speeding Tickets

John: *It looks like there is a negative relationship between the age of drivers and the number of speeding tickets, i.e., as age increases the number of speeding tickets decreases or as age decreases the number of speeding tickets increases.*

Sarah: *I don't think that young females deserve the label of driving too fast.*

Do females get fewer speeding tickets than males? Find out if there is a relationship between the sex of the drivers, their age and the number of speeding tickets. Use the information in the table.

Remember the steps in finding a correlation:

- group the data in terms of the control variable
- make a graph for each data group
- plot the data
- draw a trend line
- identify the relationship

Speeding Tickets Issued By Belleville Police Force - May 1989
Number of Speeding Tickets

Age Group	Female	Male
16-20	1	16
21-25	5	15
26-30	3	11
31-35	2	11
36-40	6	9
41-45	4	8
46-50	1	2
51-55	5	3
56-60	1	2
61-65	3	0
66-70	0	2

Optional Exercise 4.3

Changing the Strike Zone

Two veteran baseball players, Frank Howard and Albie Pearson, were talking about their careers in the major leagues. In 1963 they were the tallest and shortest players in the game. Frank Howard thought that his size was an advantage in getting walks: he was so big (6' 7") that pitchers were very careful with him. Albie Pearson also thought his size (5' 5") was an advantage because his strike zone was so small. They asked Mickey Mantle who played in the same era for his view. He thought that height didn't matter; it was the size of the strike zone that was most important. Mantle thought that he got more walks before 1963 (when the strike zone was made larger) than he did after.

Use the information in the chart to find out if the height of a baseball player makes a difference to how many walks he gets. Be sure to control for the size of the strike zone by making two separate charts: one chart showing the relationship between height and walks in 1962; the other showing the relationship between height and walks in 1963.

Batter Height	Walks in 1962*	Walk in 1963**
Level 1 (shortest)	55	42
Level 2	53	40
Level 3	54	41
Level 4	55	39
Level 5	54	33
Level 6	54	30
Level 7	55	27
Level 8 (tallest)	53	25

*In 1962 the strike zone was smaller. Any pitch between the batter's shoulders and the top of the knees was a strike.

**In 1963 the strike zone was larger. Any pitch between the batter's shoulders and the bottom of the knees was a strike.

What would happen if the strike zone was changed again?

LESSON 4

ANSWER SECTION

Answers to Exercise 4.1

1. Big people can lift more than small people so keep the weight of the lifter the same.

2. More toppings mean a higher price so if you want to know if the size of pizza is related to its cost, keep the number of toppings the same.

3. Heather's dog gets treats all day long; Sarah's doesn't. If you want to know if the size of the dog is related to how much the dog eats at supper, keep the number of snacks the same.

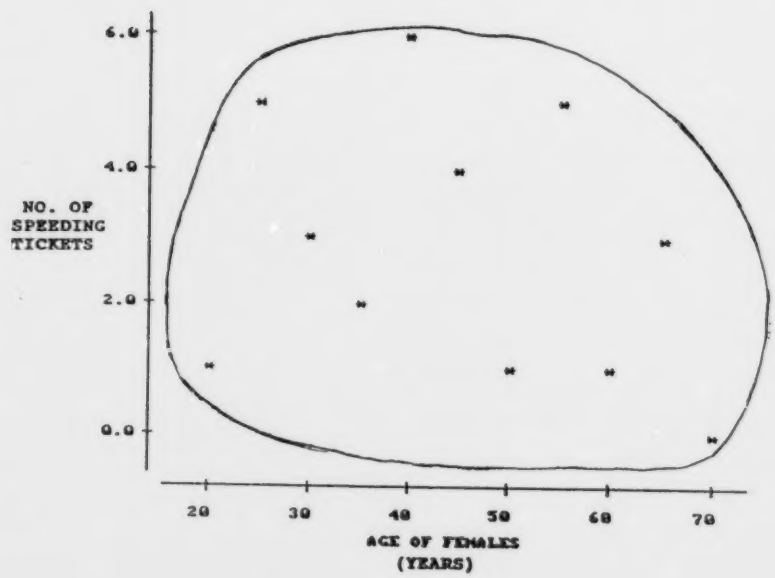
4. The quality of the soil affects the growth of bushes. If we want to find out if the growth of bushes is related to amount of sunlight, keep the soil the same.

5. Fred loves to play Nintendo and plays every chance that he can. His sister doesn't like the game and hardly plays at all. If you want to know if being a girl or boy is related to scores in *Super Mario Brothers*, keep the amount of experience in the game the same.

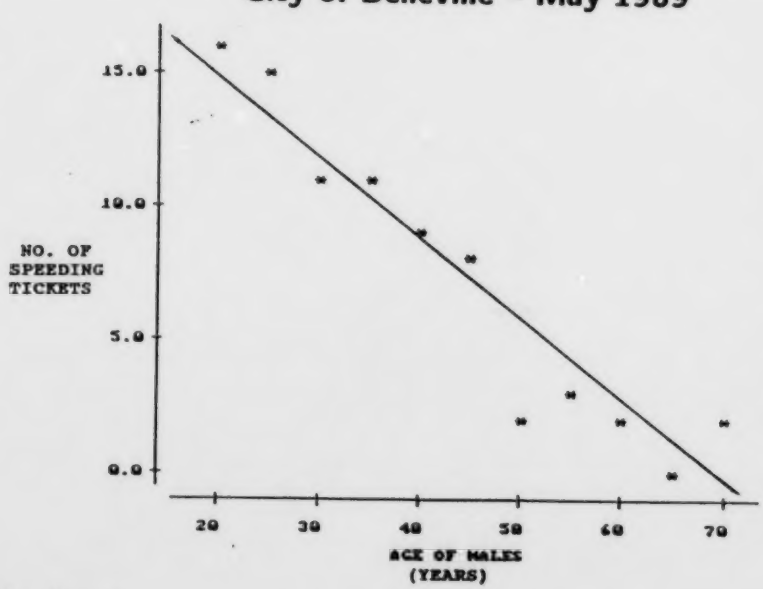
Answer to Exercise 4.2

There is a non-correlation for females. There is no relationship between the age of females and the number of speeding tickets. There is a negtive correlation for males. As the age of males increases, the number of speeding tickets increases.

Age and Number of Speeding Tickets for Females
City of Belleville - May 1989



Age and Number of Speeding Tickets for Males
City of Belleville - May 1989



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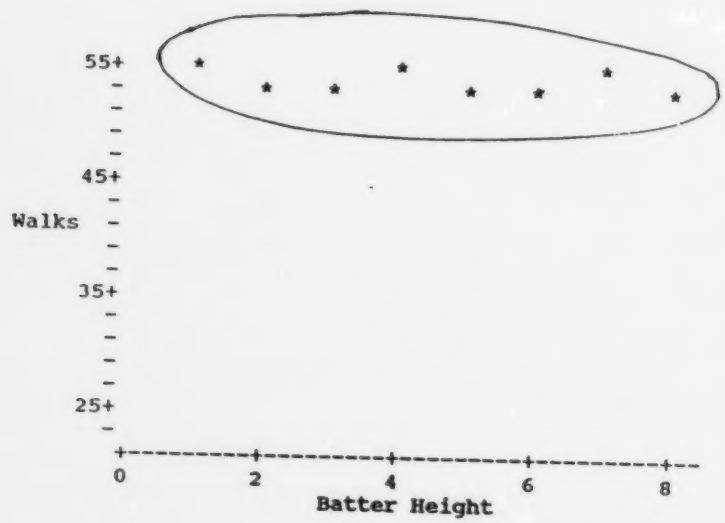
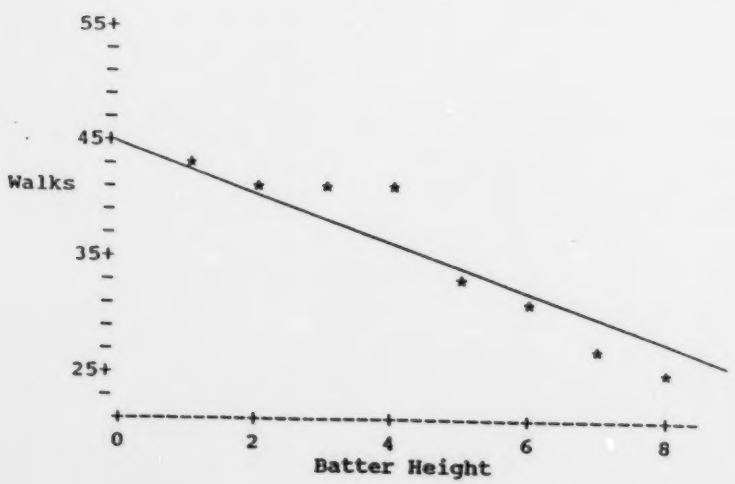
Answer to Optional Exercise 4.3

The results show that in 1962 there was a non-correlation; there was no relationship between height and number of walks. In 1963, there was a negative correlation, as the height of batters increased, the number of walks decreased. Changing the strike zone affected the tall players, but not the short ones.

Walks in 1962



Walks in 1963



Lesson 5

Controlling Variables In Geographic Problems

Learning Outcomes

1. To be able to control variables when organizing and interpreting correlational data in geographic problems.

Suggested Teaching Strategy

1. Assign Exercise 5.1 and provide students with the data in the table (Snowfall and Average January Temperature for Cities in Canada). The relationship between the two variables is different when you look at the variables in terms of coastal versus inland locations. The answers are found in the Answer Section. The average January temperature is unrelated to snowfall for cities located on the coast, and is negatively related to snowfall for cities located inland.

2. Assign Exercise 5.2. In this exercise students must find the correlation between weight of garbage produced by a family and the number of family members, controlling for recycling habits.

3. Assign Exercise 5.3. In this exercise the students must identify the uncontrolled variable that is creating a misleading result. Have the students identify additional examples.

4. OPTIONAL: For independent study, have students design and carry out a correlational investigation. For example, students might find the correlation between water consumption and number of people living in a dwelling, controlling for season (summer and winter).

Evaluation

1. Once again feedback should focus on the need to control variables, especially in geographic problems when there are so many factors which can influence a relationship.

2. Assign Quiz #2. A marking scheme for Quiz #2 is included.

Exercise 5.1

Let It Snow, Let It Snow, Let It Snow

Andrew and Tara were trying to plan a ski trip for their high school's Alpine Ski Club. Tara wanted to make sure that they picked a Canadian destination where there would be lots of snow.

Don't worry about that," and Andrew, *"all we have to do is pick a place that is really cold."*

"What do you mean by that?" replied Tara.

"Everyone knows that the colder the temperature, the more snow you get," said Andrew.

"I don't know about that Andrew," said Tara, *"I think it is a little more complicated. I think we should take a look at some climate statistics for Canada before we make our decision*

(a) Is Andrew right? Use the information in the table to find out if snowfall and temperature are related.

(b) What kind of correlation is this?

(c) What will happen to the snowfall, if the average January temperature decreases?

SNOWFALL AND AVERAGE JANUARY TEMPERATURE FOR CITIES IN CANADA BETWEEN 44 AND 54°N

CITY	LOCATION	AVERAGE JANUARY TEMPERATURE (°C)	SNOWFALL (cm)
St. John's	Coast	- 4	364
Charlottetown	Coast	- 7	305
Montreal	Inland	- 9	243
Ottawa	Inland	-11	216
Yarmouth	Coast	- 3	205
Calgary	Inland	-12	154
Edmonton	Inland	-15	132
Sydney	Coast	- 4	288
Saint John	Coast	- 7	217
Regina	Inland	-17	115
Chatham	Coast	- 9	309
Winnipeg	Inland	-18	131

Exercise 5.2

People Make Garbage

Angel and Tamil both live near a land fill site and they are very concerned about the amount of garbage that is produced in their community.

Angel: *Some people just don't care. The family next door to us puts out at least 8 bags of garbage every week. There ought to be a law that nobody can put out more than 3 garbage bags per week.*

Tamil: *Not so fast Angel. What matters is the weight of garbage, not how many bags it is in. And what about the size of the family? Large families probably produce more garbage than small families.*

Angel: *I don't think that's true about the size of the family. What counts is whether they are recycling.*

Angel and Tamil decided to investigate the question. They collected information on the weight of garbage put out by each family. They recorded the number of people in the family and recycling habits (whether or not the family used a blue box and a compost pile).

Use the information collected to find out if there is a relationship between size of family and amount of garbage produced. Make sure you remember to control for recycling habits.

Family	Number of Members	Weight of Garbage	Recycling Habits
Armitage	2	8	no
Balson	6	18	no
Carlson	3	2	yes
Duncan	9	27	no
English	2	3	yes
Fuller	1	2	no
Gillespie	4	2	yes
Horvath	7	6	yes
Ibey	10	8	yes
Johnstone	1	5	no
Kay	3	3	yes
Lawler	8	5	no
Munson	2	6	yes
Newman	3	1	yes
O'Toole	4	12	no
Porter	2	2	yes
Roberts	4	4	yes
Scott	3	7	no
Thompson	3	8	no
Urbach	8	21	no

Exercise 5.3

Find The Missing Variable

In each of the following items there is a relationship between two geographic variables. There are no controls. Your task is to determine what should be controlled.

1. **Relationship:** The number of frost-free days is positively correlated with the production of winter wheat in Canada.

   Clue: The area of Canada which has the longest frost-free period is southwestern British Columbia, yet they produce very little wheat in comparison to the area of Canada with the second longest frost-free season--southern Ontario and southwestern Quebec. **Why?**

2. **Relationship:** There is a positive correlation between the location of pulp and paper mills and forested areas. Pulp and paper plants are located near the forests to cut down on transportation costs.

   Clue: One of Canada's leading forestry companies is planning to build a pulp and paper plant in Montreal, a long way from the forests. **Why?**

3. **Relationship:** The amount of mineral mined is related to the size of the mineral deposit.

   Clue: Although the arctic region in Canada is very rich in mineral resources, very few of these large reserves have been tapped. In contrast, areas in northern Ontario and Quebec which support much smaller reserves have been mined dry. **Why?**

QUIZ 2

ENERGY USE

Ryan and Meg are very concerned about nuclear power.

Ryan: *We wouldn't have to build any new power plants if people would insulate their houses properly.*

Meg: *That's not the answer. Even if houses are well insulated they use a lot of energy. The problem is that the houses are too big.*

Meg and Ryan collected information on the amount of energy consumed during the past winter for houses that are heated electrically. They recorded the number of square feet and the insulation standard used in the house construction.

Use the information in the table to find out if the size of the house makes a difference to how much energy is used.

Family	Number of Square Feet	Energy Use (in 000 kw)	Insulation Standard*
Archer	1075	13	new
Bell	3800	40	new
Cameron	2050	24	new
Donnelly	650	16	old
Effingham	1050	18	new
Franklin	2200	41	old
Horley	2075	36	old
Ingram	920	10	new
Jacks	970	21	old
Knowles	1475	22	new
London	810	17	old
McMullen	900	23	old
Nottingham	875	20	old
Orme	3100	35	new
Palin	1300	17	new
Rees	780	19	old
Sullivan	3100	54	old
Temple	1500	28	old
Ulbani	2075	26	new
Gilmore	1900	21	new

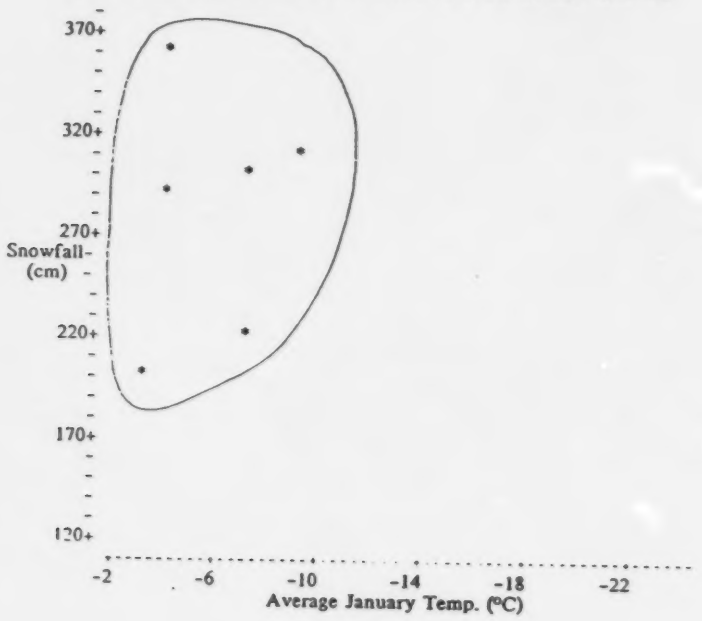
*for new houses the standard was R40 in the ceiling, R20 in the walls and R12 in the basement; for old houses the standard was R20 in the ceiling, R10 in the walls and there were no requirements for the basement.

LESSON 5

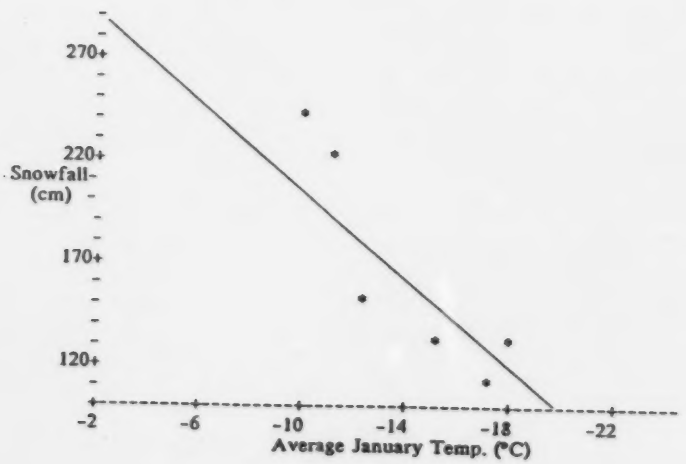
ANSWER SECTION

Answer to Exercise 5.1

Snowfall And Average January Temperature For Cities In Canada On The Coast Between 44 N And 54 N



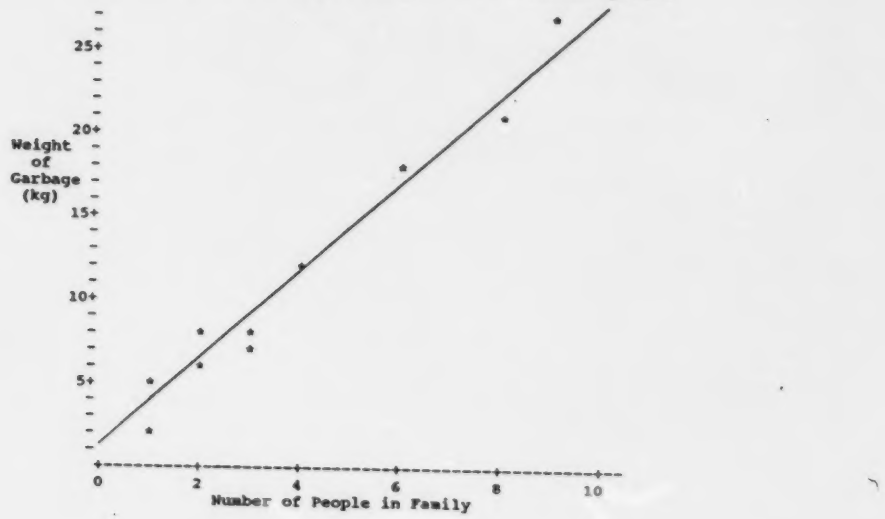
Snowfall And Average January Temperature For Cities In Canada Inland Between 44 N and 54 N



Answer To Exercise 5.2

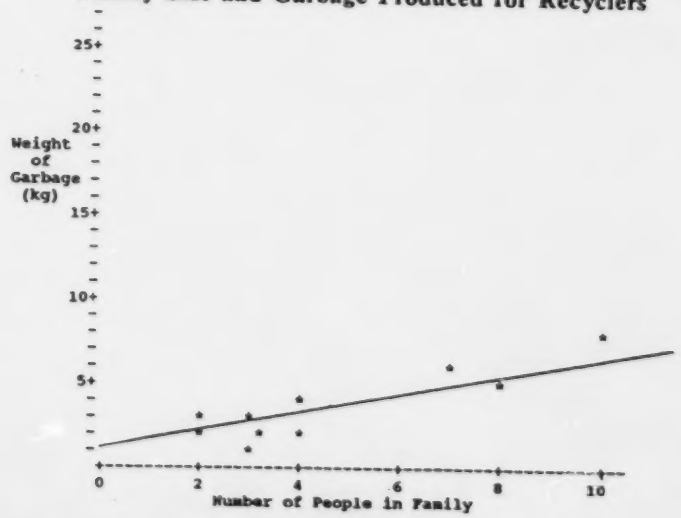
The first graph shows there is a positive correlation. The weight of the garbage produced increases, as the number of people in non-recycling families increases. The second graph shows there is a positive correlation. The weight of garbage produced increases as the number of people in recycling families increases, but not to the same degree as non-recycling families.

Graph A
Family Size and Garbage Produced for Non-Recyclers



Conclusion: Graph A shows a positive correlation: the weight of garbage produced increases as the number of people in non-recycling families increases.

Graph B
Family Size and Garbage Produced for Recyclers



Conclusion: Graph B shows a positive correlation. The weight of garbage produced increases as the number of people in recycling families increases, but not to the same degree as in non-recycling families.

Answers To Exercise 5.3

1. Southwestern British Columbia is located in the Western Cordillera and has very little level land suitable for agriculture. Southern Ontario and southwestern Quebec are located in the Great Lakes-St. Lawrence Lowlands which is composed largely of level land and gently rolling hills--ideal for agriculture. Therefore we must control for physiographic region.

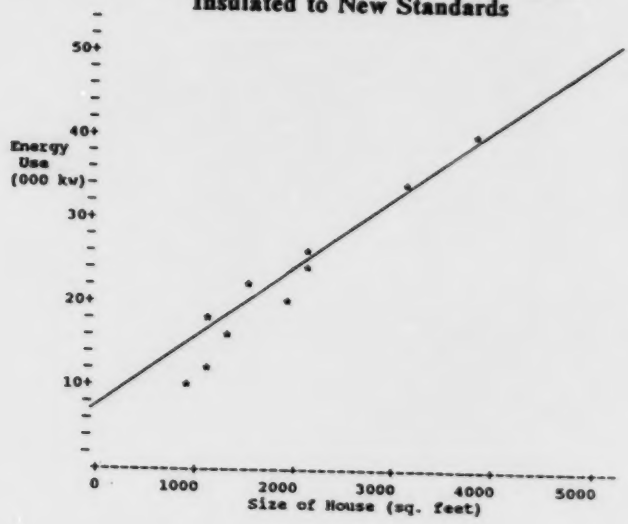
2. Control for time of plant construction. In the last few years there has been a push toward recycling. Almost half of new newsprint is made up of recycled newspapers. New plants will be built near the population that recycles newsprint, rather than near the forests.

3. Control for transportation costs because the closer the mineral deposit to the city where processing occurs the lower the transportation costs. The costs to transport minerals from the Arctic for processing would be very high in comparison to shipping minerals within Ontario and Quebec.

Answer To Quiz 2

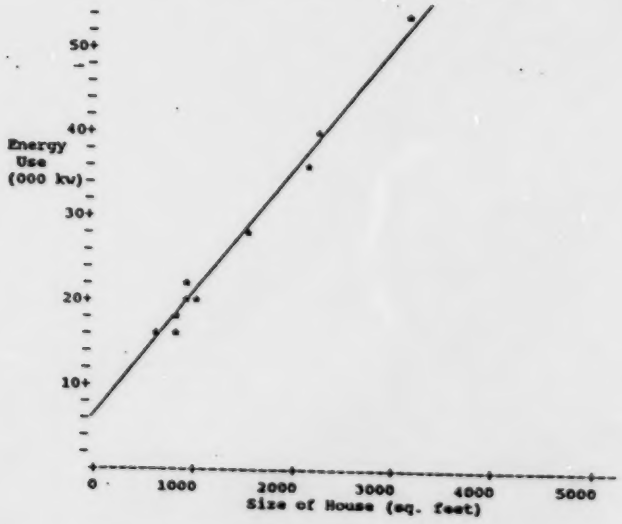
The first graph shows there is a positive correlation. Energy use increases, as house size increases for houses insulated to the new standard. The second graph shows there is a positive correlation. Energy use increases as home size increases for houses insulated to the old standard. Energy use is influenced by size of house and insulation standard.

Graph A
Size of House and Energy Use for Houses Insulated to New Standards



Conclusion: There is a positive correlation. Energy use increases as home size increases for houses insulated to the new standard.

Graph B
Size of House and Energy Use for Houses Insulated to Old Standards



Conclusion: There is a positive correlation. Energy use increases as home size increases for houses insulated to the old standard. Energy use is influenced by size of house and insultation standard.

MARKING QUIZ 2

Make a Graph - 10 marks for each graph [20 marks total)

- names each axis — 2 marks
- puts in horizontal scale — 3 marks
  - * from lowest score (1 mark)
  - * to highest score (1 mark)
  - * in equal units (1 mark)
- puts in vertical scale — 3 marks
- labels graph — 2 marks

Put Information in the Graph - 5 marks for each graph

- puts all data in graph correctly — 5 marks
  - * 3 marks if one error
  - * 1 mark if two errors

Read the Graph - 10 marks total

- draws a line through the cases — 4 marks
  - * (2 marks for each graph)
- correct conclusion — 6 marks
  - * (3 marks for each graph)

MAXIMUM SCORE: 40 MARKS